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FOREST GROUSE and EXPERIMENTAL SPRUCE BUDWORM INSECTICIDE STUDIES

by

Thomas W. Mussehl and Philip Schladweiler

Research Section

Game Management Division

MONTANA FISH AND GAME DEPARTMENT

Technical Bulletin No. 4

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Photo by Danny On

FOREWORD

It is my strong belief that *a clean environment for wildlife is a quality environment for man.* This department has been critical of the use of persistently toxic insecticides since the widespread use of DDT on public forests began in the early "fifties." We have been in full agreement with the President's Science Advisory Committee report of 1963 which recommended the orderly reduction of release of persistent pesticides into the environment. We applaud the subsequent decision to cease use of DDT on National Forests and the recent announcement by the U. S. Department of Agriculture to further curtail use of the "hard" pesticide group.

Along with the technical findings in the search for safer insecticides, another value of this study has been to exemplify the merits of federal-state cooperative research efforts in seeking solutions to maintain or acquire a quality environment.

Frank H. Dunkle

FRANK H. DUNKLE, DIRECTOR
MONTANA FISH AND GAME DEPARTMENT

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Photo by Gerry Atwell

INTRODUCTION

Spruce budworm *(Choristoneura fumiferana)* was first recognized as a problem in western forests in 1922, when two distinct outbreaks occurred in Idaho (Whiteside and Carolin 1961). Until 1944, according to the same authors, spruce budworm epidemics in the western United States generally lasted from 3 to 5 years and then subsided from natural causes. They reported continuing budworm epidemics in Idaho, Oregon and Montana after 1944. Forest managers recognized the spruce budworm as a potential threat to vast acreages of timber. By the mid-1940's, DDT had received worldwide recognition as a new insecticide and in 1949 aerial spraying of DDT for budworm control began on western forests. One pound of DDT per acre became the standard tool to combat forest insects. From 1952 to 1963 nearly 3 million acres of Montana forests (primarily Douglas-fir) were sprayed with DDT. According to Rudd (1964:27), spruce budworm operations with DDT probably covered more continuous acres than any other spraying scheme, possibly 20 million acres.

The shortcomings of DDT were more slowly recognized than were its insecticidal qualities. Numerous studies, including those by Graham (1958) in Montana, indicated the detrimental effects of DDT spraying on aquatic life, including trout. Earlier studies on forest game indicated no direct effects to birds and mammals after 1.0 pounds of DDT per acre (Adams *et al.* 1949 and Hoffman *et al.* 1958). Studies initiated by the U. S. Fish and Wildlife Service in 1959 indicated retention of DDT-type residues in game animals following spruce budworm spraying (Pillmore and Finley 1963).

Pesticides received increased attention after the best-selling book *Silent Spring* by Carson (1962) presented an alarming exposé of pesticide misuse and the probable consequences. Interest in pesticide and wildlife-pesticide research was stimulated by Carson's book, and the undesirable characteristics of DDT became more widely recognized. In 1963 the President's Science Advisory Committee (PSAC 1963:20) recommended that agencies of the Federal Government restrict the wide-scale use of persistent insecticides except for necessary control of disease vectors.

Residues of DDT found in Montana forest grouse after spruce budworm spraying in 1963 resulted in warnings to hunters from the U. S. Food and Drug Administration (Mussehl and Finley 1967). In 1964 the Montana Fish and Game

Commission requested the discontinuance of the use of chlorinated hydrocarbons on public lands and urged that intensive field evaluations of new insecticides be conducted (Smith and Mussehl 1964).

The U. S. Forest Service began field trials of experimental spruce budworm insecticides in Montana in 1963. Two organo-phosphates with much shorter persistence than DDT were tried. Application of phosphamidon at the rate of 1.0 pounds per acre resulted in immediate adverse effects to bird life, including forest grouse, on a 5,000-acre spray block (Finley 1965). Malathion, however, was used in a large-scale budworm spraying operation in 1964 with no adverse effects to wildlife reported.

In 1965 the U. S. Forest Service initiated an intensive research effort in western Montana to find suitable insecticides for spruce budworm control. Research personnel from the Southwest Forest and Range Experiment Station at Berkeley, California were assigned the responsibility of field testing candidate budworm insecticides on study sites within the Bitterroot National Forest, and the U. S. Bureau of Sport Fisheries and Wildlife (Denver Wildlife Research Center) undertook related pesticide-wildlife studies. The Bureau provided a research contract to the Montana Department of Fish and Game to undertake studies on forest grouse to supplement forest insecticide-wildlife research efforts.

This bulletin presents our evaluations of two experimental spruce budworm insecticides on forest grouse species in field and pen tests during 1965 through 1967.

ACKNOWLEDGEMENTS

This project was a contract research endeavor between the Montana Fish and Game Department and the United States Bureau of Sport Fisheries and Wildlife. Personnel from the Denver Wildlife Research Center provided valuable assistance, advice, and cooperation in initiating and maintaining this project. The success in completing it depended greatly upon numerous personnel and cooperators from several other agencies. Forest Service personnel from the Pacific Southwest Experiment Station, Berkeley, California, the Bitterroot National Forest and the Regional Office at Missoula, Montana provided considerable assistance. Several scientists from the Rocky Mountain Public Health Service Laboratory at Hamilton, Montana aided materially by providing advice and laboratory facilities. Telemetry equipment was loaned to the project in 1965 by the Idaho Fish and Game Department and the Denver Wildlife Research Center and by the University of Minnesota in 1965 and 1966. Mr. and Mrs. George Lentz provided base camp facilities in the West Fork area and the use of tools for maintenance and construction of field equipment.

Fish and Game Department personnel on seasonal assignment to this project were: in 1965, Neil Martin and Clait Braun; 1966, Kenneth Sumanik, Neil Martin and Richard Wallestad; 1967, Ronald Stoneberg and Robert Martinka. Additional assistance and vehicles were supplied by Fish and Game Department personnel of District No. 2, Headquarters, Missoula. The State Game Farm at Warm Springs provided facilities and assistance in conducting tests with penned birds. The State Hospital at Warm Springs provided laboratory facilities for preparing insecticide formulations.

The cover design was by Bob Earhart and F. W. Howell of Butte, Montana. Top and bottom cover photographs were by Mr. Dan On of the U. S. Forest Service, Missoula, and Robert Martinka of the Montana Fish and Game Department, respectively. All other photographs were by project personnel except as indicated. Manuscript typing and assistance in preparation was by Game Research Section secretary, Mrs. Elizabeth Lemons. The manuscript was critically reviewed by Richard Pillmore and Mrs. Ann Jones of the Denver Wildlife Research Center.

Photo by Gerry Atwell

METHODS AND MATERIALS

Study Plans and Emphasis

Blue grouse *(Dendragapus obscurus pallidus)* received the greatest study emphasis because of their relative abundance, their affinity for semi-open forest cover and the ease of observing and capturing them as compared to other forest grouse. Blue grouse males have a high fidelity in returning to their breeding territories each spring and perform a conspicuous courtship display (Figure 1). Since males abandon territorial areas during late June and early July, the timing of spray application is an important consideration. Blue grouse females with broods generally remain on summer areas until late July or August. Both sexes are relatively easy to capture, mark and observe in the wild.

Ruffed grouse *(Bonasa umbellus umbelloides)* and spruce grouse *(Canachites canadensis franklinii)* were more limited in abundance and distribution on the study areas. Their habits and preference for dense cover made them much more difficult to locate and observe than blue grouse.

The primary study approaches included:

1. Direct pre- and postspray observations, some with the aid of radio telemetry, of blue and ruffed grouse exposed to aerially sprayed insecticides.
2. Comparison of breeding male blue grouse populations on sprayed and unsprayed study units one year after insecticide application.
3. Determination of the annual survival rate of banded, adult blue grouse males on sprayed and unsprayed areas.
4. Oral dosing of various forest grouse species to determine the relative acute oral toxicity of Zectran and to observe signs of poisoning.

Study Areas

A 54,000-acre area of the Bitterroot National Forest of Montana was designated as an experimental area for spruce budworm control in 1965. This area was located in the West Fork area of the Bitterroot and ranged in elevation from 4,000 to 7,000 feet. Actual spray treatments were applied by the Forest Service to areas ranging in size from 1,080 to 4,500 acres. Grouse study units were on sub-units of the experimental spray areas (Table 1, Figure 2). Grouse study units were located mainly within the ponderosa pine zone described by Daubenmire (1953). The semi-open pine is interrupted by Douglas-fir thickets, with mixed pine and fir at the upper elevations.

TABLE 1. GROUSE-INSECTICIDE STUDY AREAS, WEST FORK OF BITTERROOT.

Year	Location	Acres	Insecticide Evaluated
1965	Tough Creek	240	Zectran
1965	Mud Creek	320	Dibrom
1965	Black & Basin Creeks	290	Non-sprayed control
1966	Mud Creek	320	Zectran*
1966	Trapper Creek-Fishhook	210	Zectran
1966	Trapper Creek-Haley Chute	390	Zectran
1966	Black & Basin Creeks	290	Non-sprayed control

*Multiple application.

Concurrent with this project, blue grouse population studies were conducted in the Skalkaho drainage of the Bitterroot National Forest 10 miles southeast of Hamilton, Montana. Blue grouse studies have been conducted on this area since 1962. The area was sprayed with DDT at the rate of 0.5 pounds per acre in 1963 (Mussehl and Finley 1967). Population surveys of male blue grouse were continued on the Skalkaho unit during 1965, 1966 and 1967 as part of Federal Aid in Wildlife Restoration Project No. W-91-R (Mussehl and Schladweiler 1967).

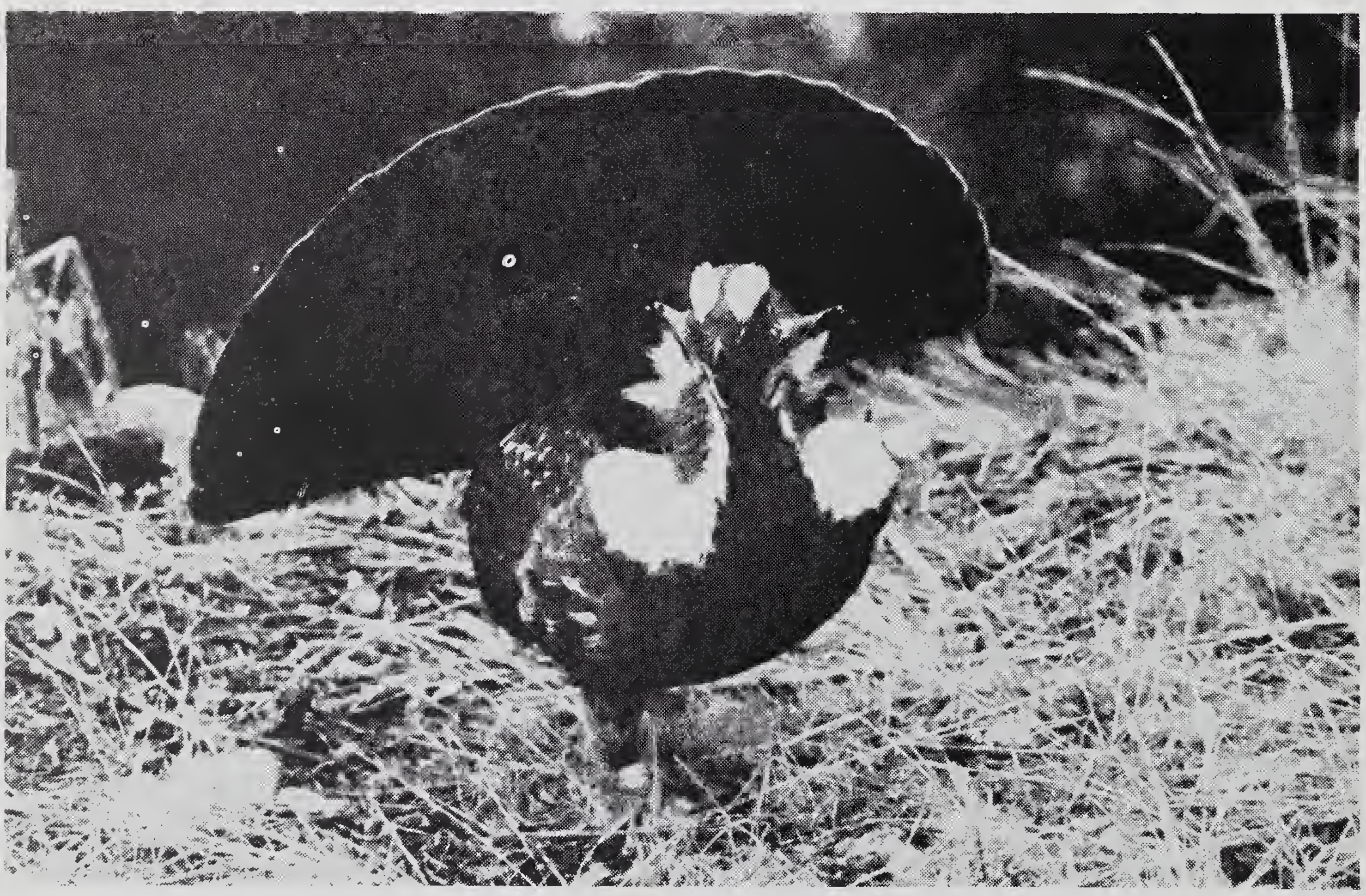


Figure 1. The blue grouse is an excellent study bird for forest insecticide trials. The males are conspicuous during the breeding season, are relatively easy to capture for banding, and have a high fidelity to return to their territories each spring. The timing of spray application is important, as males begin to abandon territorial areas during late June and July.

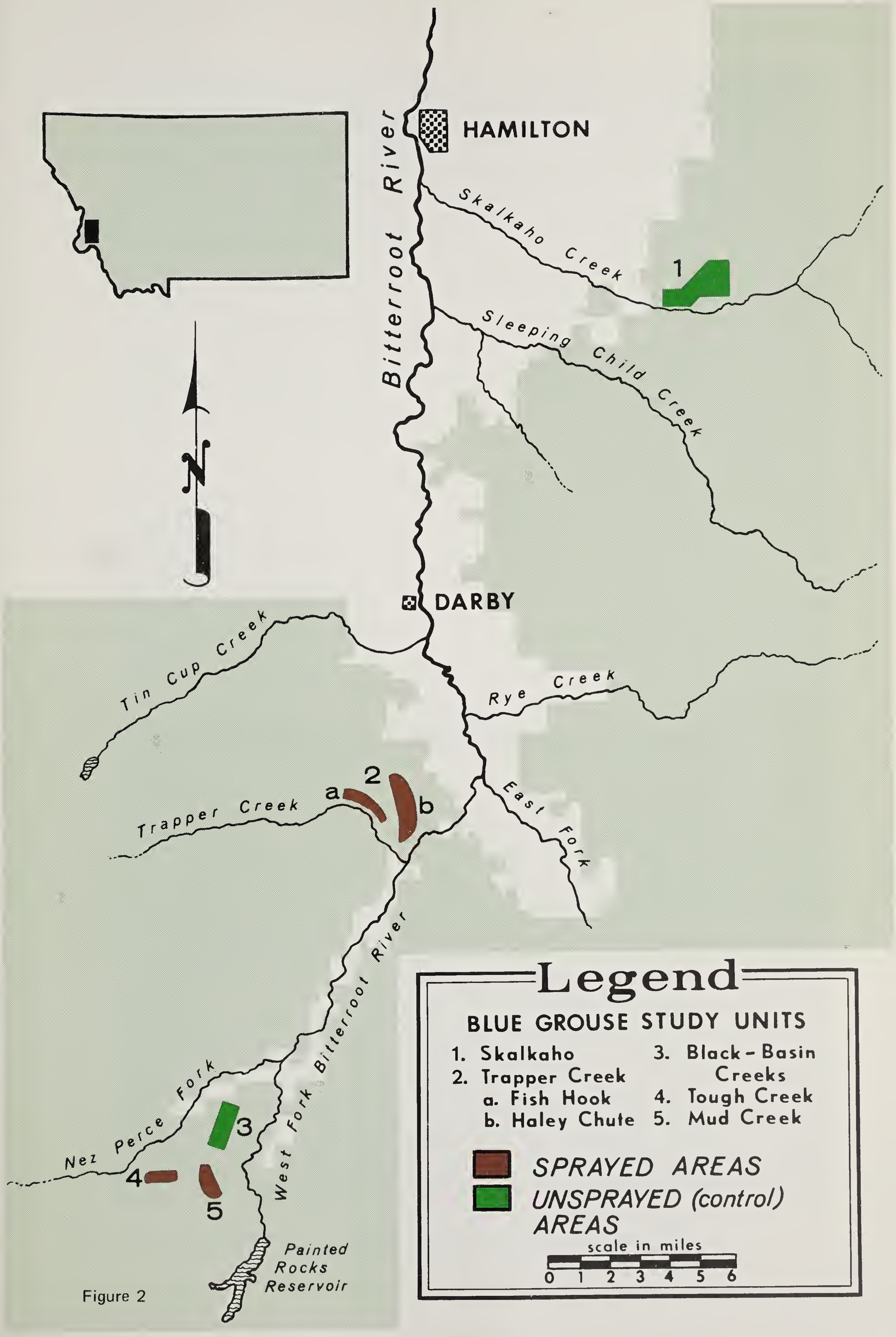

HAMILTON
DARBY
Bitterroot River
Skalkaho Creek
Sleeping Child Creek
Rye Creek
East Fork
Tin Cup Creek
Trapper Creek
West Fork Bitterroot River
Nez Perce Fork
Painted Rocks Reservoir
N
1
2
a
b
3
4
5
Legend
BLUE GROUSE STUDY UNITS
1. Skalkaho
2. Trapper Creek
a. Fish Hook
b. Haley Chute
3. Black-Basin Creeks
4. Tough Creek
5. Mud Creek
SPRAYED AREAS
UNSPRAYED (control) AREAS
scale in miles
0 1 2 3 4 5 6

Figure 2

Field Methods

Blue grouse were located by walking and driving through breeding areas during morning and evening activity periods. Periodic listening stops were made to detect courtship noises. Recorded female calls were used to attract and locate males (Stirling and Bendell 1966). Blue grouse broods were located by foot and vehicle searches with the assistance of a pointing dog and the use of imitated chick distress whistles.

Ruffed grouse males were located by walking and listening for drumming sounds. Ruffed grouse males were captured for banding with mirror traps (Gullion 1965). Spruce grouse were located by using a specially trained pointing dog.

Most blue grouse and spruce grouse were captured (Figure 3) with 24-foot telescoping, fiberglass poles equipped with plastic-coated wire nooses (Zwickel and Bendell 1967). A few blue grouse hens and broods were captured by use of a 10 by 60-foot heavy gauge mist net (Figure 4), as described by Schladweiler and Mussehl (1969).

Captured grouse were individually marked with standard Fish and Game Department aluminum leg bands and numbered plastic "Bandettes." Band combinations usually consisted of two plastic bands, one standard aluminum band and a numbered, colored aluminum band as described by Hamerstrom and Mattson (1964). Juvenile grouse less than 6 weeks of age were tagged with "Jiffy" wing bands. Field identification of banded grouse was aided by use of binoculars (8 x 30) and spotting scopes (20x and 15-60x).

The radio telemetry equipment used was purchased from Sidney Markusen, Electronics Specialties, Esko, Minnesota. This system has been described by Marshall and Kupa (1963) and Marshall (1963). Operation is in the very high frequency (VHF) range. The receiver is small, lightweight and easily carried in the field (Figure 5). A directional two-element Yagi antenna is carried by hand. Each transmitter has

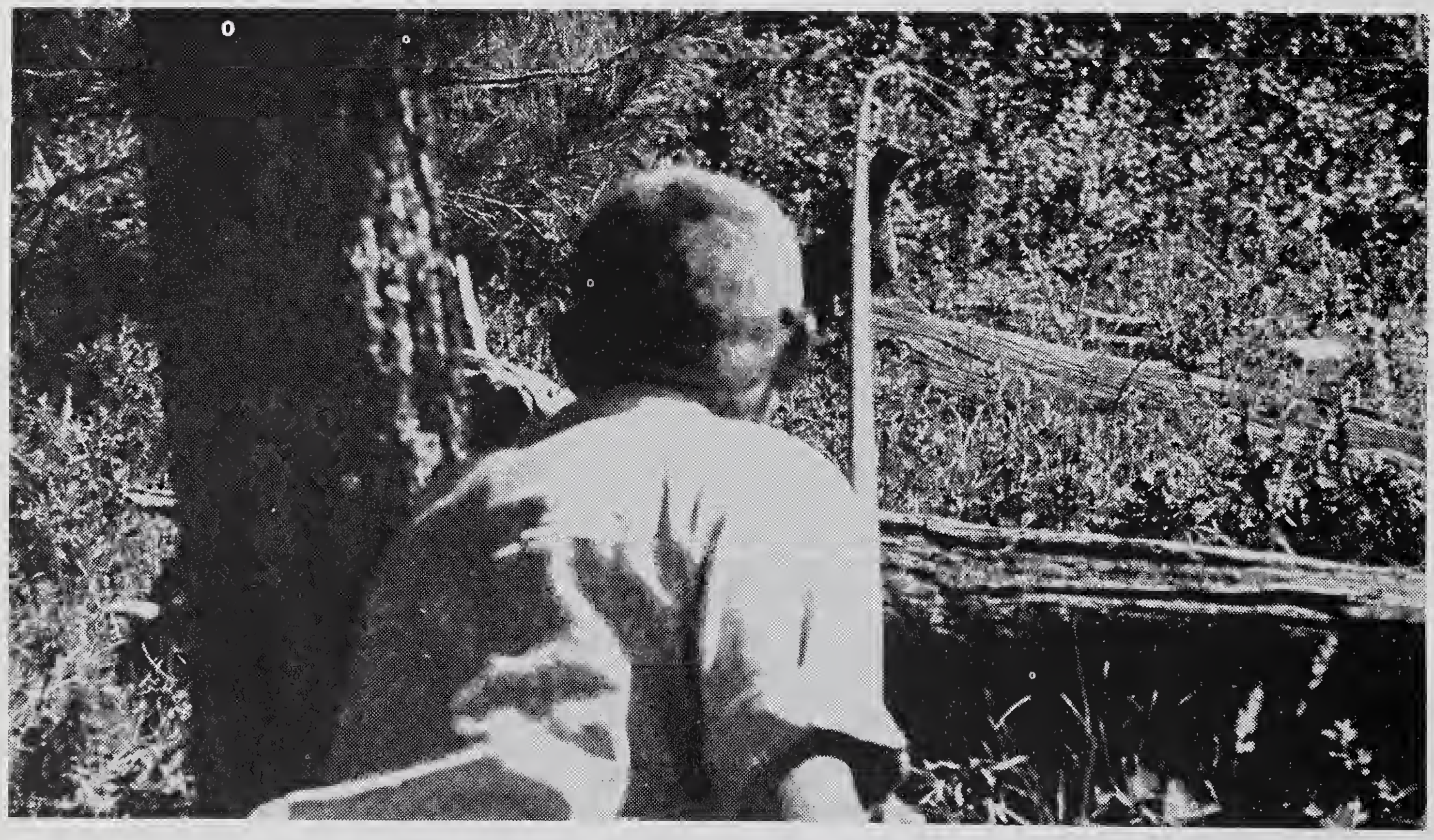


Figure 3. Adult blue grouse were captured for banding with 20-foot, telescoping noosing poles. This territorial male was captured, banded, and released prior to the 1966 Zectran application on Trapper Creek.

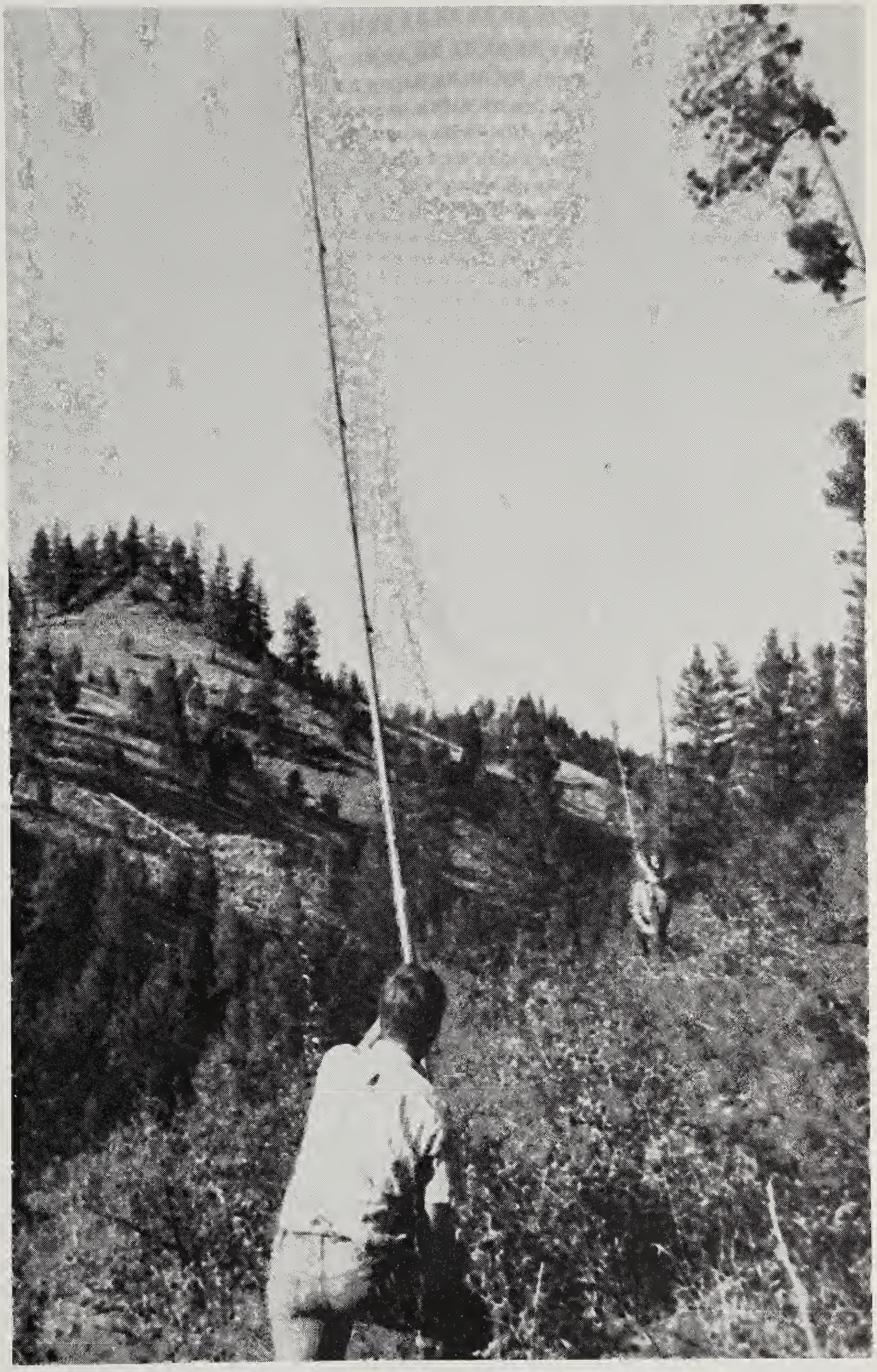


Figure 4. A 10 x 60-foot mist net was used to recapture specific blue grouse for examination, oral dosing, and placement or retrieval of transmitters. Two men positioned the net downhill from the grouse and a third observer flushed the grouse towards it.

a discrete frequency between 150.815 and 151.085 megacycles. The transmitter is equipped with a 12-inch whip antenna of fine wire and is harnessed (Brander 1968) to ride on the back of the bird (Figure 6). The complete transmitter package weighs from 20 to 45 grams, depending on the battery used. Changes in signal attenuation resulting from movement of the transmitter and antenna can be interpreted to indicate certain grouse activities (Marshall 1965 and McEwen and Brown 1966). An eight-element antenna mounted on a 20-foot rotating mast was installed on the Mud Creek ridgetop to monitor instrumented grouse signals at night.

Instrumented grouse were usually located by approaching within 200 yards and obtaining successive bearings from several angles (Cochran and Lord 1963). Locations were plotted to the nearest 1/16-inch on gridded 8-inch/mile aerial photos. The telemetry location was often verified by visual observations.

Spray deposit distribution was recorded by using oil sensitive cards and the fluorescent particle method of Himel *et al.* (1965). In each blue grouse male territory four cards were placed at the corners of an approximate one acre rectangle encompassing the center of the male's activity. Exposed spray cards were analyzed with the assistance of Pacific Southwest Forest and Range Experiment Station personnel.

Vegetation samples, including preferred summer grouse foods, were collected before and at daily intervals after Zectran spraying in 1966 and submitted to the U. S. Forest Service Laboratory at Berkeley, California for Zectran residue analysis.

Pen Test Methods

Oral dosing experiments were conducted with forest grouse and pheasants at the Hamilton Field Station, the Warm Springs State Bird Farm and in the field. Observations of birds dosed in 1965 and 1966 at Hamilton were made in a 3¼-by 2½-by 24½-foot concrete tank with a wire mesh top. A net across the middle of the tank separated experimental birds from undosed birds. Food and water were usually withheld from experimental birds for 18 to 26 hours prior to dosing.

Observations at the State Bird Farm were made with binoculars and a 20x spotting scope through the open window of a brooder house occupying a 10-by 12-foot corner of a 90-by 35-by 6½-foot pen. Food and water were available in the pen at all times. All birds dosed in 1965 and 1966 were observed for a minimum of 1 hour, or until death or signs of recovery.

The 1967 oral dosing experiments were conducted in the field in 1-by 1-by 2-foot wire mesh holding cages. Wild-captured birds were dosed as soon as possible after capture. This meant birds were without food and water for varying periods, especially the ruffed grouse, whose exact time of capture in the mirror traps was unknown. Continuous observations were not made on birds dosed in 1967.

Most birds were subjected to single acute oral doses. In 1965, four pheasants *(Phasianus colchicus)* and two blue grouse received chronic oral doses once or twice a day for 2 to 8 days. One pheasant receiving an oral dose of granulated sugar twice daily for 7 days served as a control.

The Denver Wildlife Research Center provided the insecticide and data on previous Zectran trials and aided in conducting initial dosing trials at Hamilton. Pure (recrystallized) Zectran was weighed, placed in No. 2 gelatin capsules and administered with a one-quarter-inch (ID) glass tube and push rod. The Zectran was

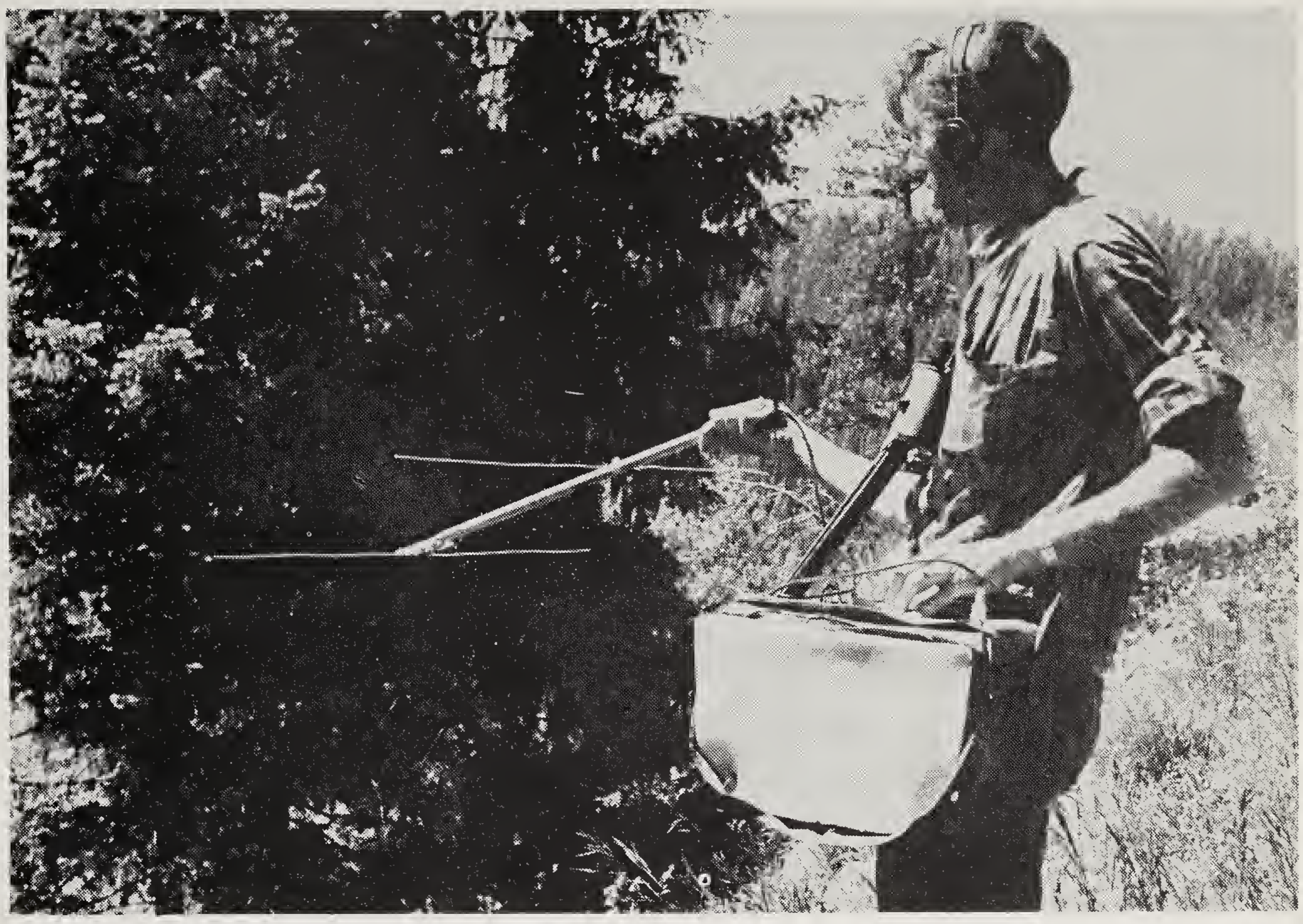


Figure 5. A portable Markusen receiver with directional, hand-held antenna was used to locate instrumented blue and ruffed grouse.

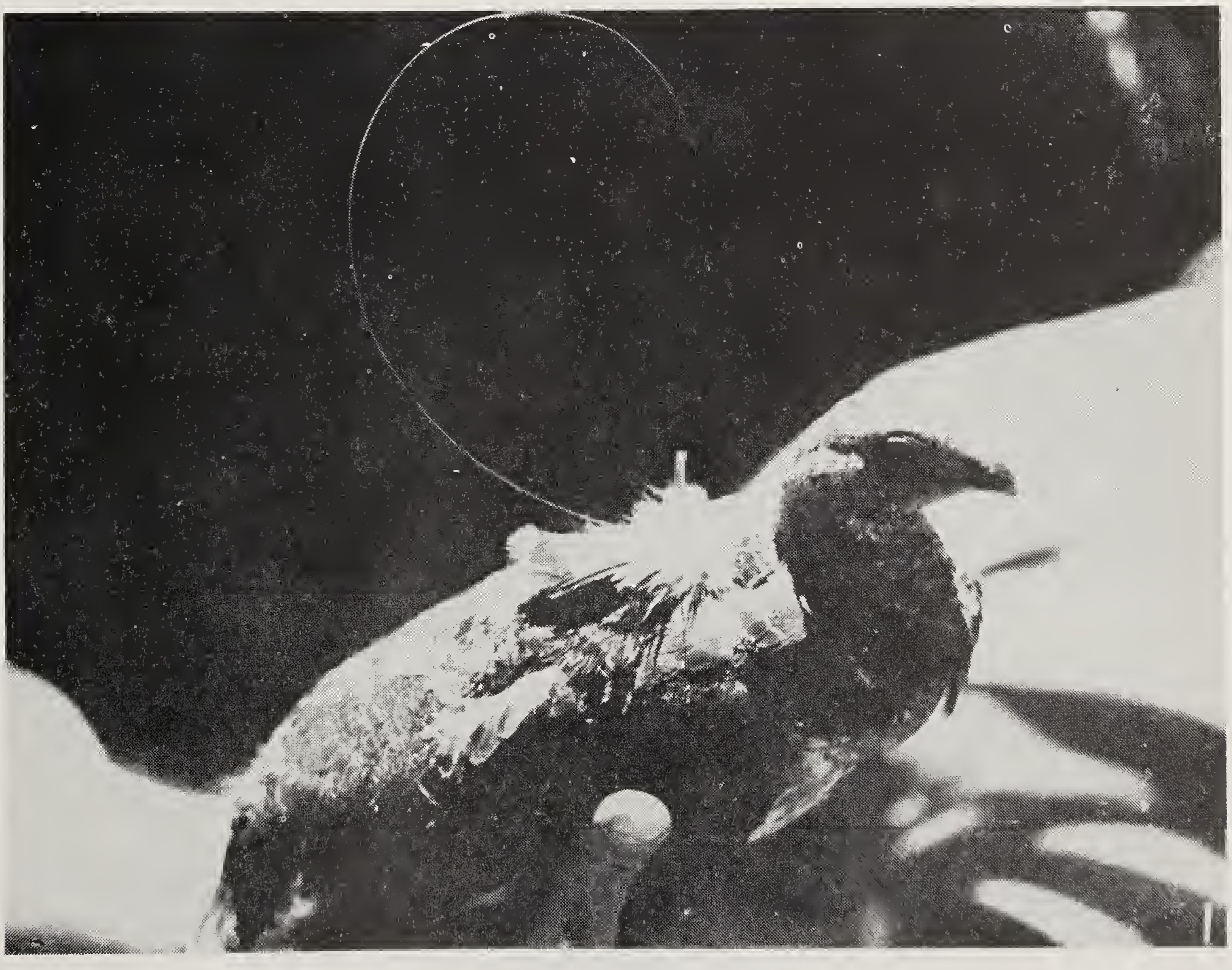


Figure 6. A blue grouse hen being instrumented with a radio transmitter.

weighed at the Rocky Mountain Public Health Service Laboratory at Hamilton, or at the State Hospital at Warm Springs. Trial birds were weighed to the nearest gram.

LD_{50}'s were estimated rather than calculated because in some cases the proper starting point or interval between dosage levels was not obtained, or a sufficient number of birds was not tested at the precise dosage required for calculation.

A 20-by 10-by 6-foot holding pen of fish netting supported by steel posts was erected on the Mud Creek study unit in 1966 to expose captive blue and spruce grouse to aerially applied Zectran.

FINDINGS

Field Studies — Blue Grouse

Blue grouse are unique among grouse species in that they winter at high elevations and descend to lower areas for breeding and brood-raising. Males are generally present on breeding areas from early April until late June or early July. Hens with broods remain on the summer range later and generally do not disperse until August. The observability of grouse in spring and summer varied with seasonal changes in their activities and the development of ground vegetation. The number of grouse observed per man-hour was highest during April and May of all years (Table 2) because of the conspicuous courtship activity of territorial males and

TABLE 2. SUMMARY OF ADULT BLUE GROUSE OBSERVATIONS PER MAN-HOUR OF SEARCH, SKALKAHO AND WEST FORK STUDY UNITS, 1965-1967.

	April	May	June-July (prespray)	June-July-August (postspray)
Tough Creek				
1965	--	1.09	0.52	0.17
1966	1.68	1.15	0.89*	--
1967	--	--	0.78	1.18*
Mud Creek				
1965	--	1.17	0.86	0.30
1966	--	1.35	1.05	0.52
1967	--	2.03	0.71	0.75
Black-Basin Creeks				
1965	--	0.83	0.66	0.40
1966	1.58	1.35	1.40	0.21
1967	--	1.65	0.58	0.64
Skalkaho				
1965	3.06	2.92	--	0.73
1966	2.71	1.73	--	0.68
1967	1.55	2.28	2.23	1.06
Trapper Creek				
1965	--	--	--	--
1966	1.08	1.10	0.72	0.37
1967	--	2.17	0.89	0.93

*Small sample size (less than 10 man-hours of search).

attendant females. A sharp decrease in numbers of grouse observed was noted in July and August when breeding activity stopped, ground vegetation increased and grouse left the study units. Observations of male grouse were more than double those of females during April, May and June. This trend reversed during July and August as males abandoned breeding territories.

Immediate postspray observations were mainly limited to a rapidly declining number of territorial males (due to egress) and to those hens with broods that could be observed in the lush, herbaceous cover. Imitated and recorded grouse calls, a trained dog and telemetry were valuable aids for locating grouse during the immediate pre- and postspray periods. The necessity of such aids in locating live grouse indicates the limited feasibility of finding dead or sick grouse by conventional searches.

Postspray observations to compare populations and survival rates of territorial males on sprayed and unsprayed areas were conducted 9-11 months following spraying, during peaks of breeding activity and male conspicuousness. As will be discussed later, spray application on some study units occurred after the major egress of males had begun.

Knowledge of seasonal changes in mobility, habitat use and observability is particularly important in evaluating the effect of a pesticide treatment on an area encompassing only a portion of an animal's home range. Awareness of these factors is essential in interpreting pre- and postspray observations and relationship of the chronology of spray application to numbers of animals exposed on specific areas.

Dibrom Evaluations — 1965

Dibrom (1,2-dibromo-2, 2-dichloroethyl dimethyl phosphate), commonly called naled, is a water-insoluble liquid organophosphorus insecticide that is highly soluble in aromatic solvents. It inhibits the neural enzyme cholinesterase, has high contact activity on a wide variety of insects and short residual action. Therefore, toxicity to insects is almost entirely due to contact action at the time of application. In tests with 12-day-old white leghorn cockerels, Sherman *et al.* (1964) reported that death from acute oral doses of several phosphates (not including Dibrom) occurred within 18 hours and was associated with convulsions. Survivors were lethargic for 6 to 19 hours after treatment.

Dibrom is reported to be considerably less toxic than most organic phosphate insecticides. Considering DDT equal to 1.0, the chronic toxicity of Dibrom to rats (*Rattus* spp.), bobwhite *(Colinus virginianus),* pheasants and mallards *(Anas platyrhynchos)* is 0.3, 3.0, 0.3 and 0.2, respectively (USDI 1963:104). It may be absorbed through the skin, inhaled or ingested to produce toxic symptons. Since Dibrom is relatively short-lived, any effects on bird life could be expected within a few days after exposure.

Prespray Studies

Attempts were made to obtain complete counts of territorial blue grouse males on the 320-acre Dibrom treatment area during May and June of 1965. Sixteen territorial males were present, 15 of which were captured and banded. In addition, 7 yearling (non-territorial) males and 17 females were banded prior to Dibrom application.

During prespray observations on the Dibrom area, there were 116 sightings of the 16 territorial males, no re-observations of the 7 yearling males, and 8 re-observations of 5 of the 17 banded females. In addition, two other females were instrumented with radio transmitters prior to spraying (July 7 and 13). Each of these females was relocated at least once daily. Fifteen relocations including five visual sightings were obtained prior to, or during, spray application. All prespray re-observations of marked birds were within the proposed Dibrom treatment area.

Four of the seven females seen prior to spraying were re-observed for the last time more than 12 days prespray. These four females were not re-observed again in 1965, so their presence on the spray area at the time of Dibrom application was unknown.

Spray Application

Dibrom was applied by a single helicopter to 1,165 acres of the Mud Creek drainage at the rate of 0.4 pounds per acre. The formulation consisted of Dibrom 14 (14 lb. active per gallon), in ethylene glycol at one pint per acre. Dibrom was applied to the Mud Creek study unit on July 15 (8:00-8:45 a.m.), 1965. Spray cards indicated complete coverage of the 320-acre study unit. Ten of the 16 territorial male blue grouse on this study unit were belived to be present during Dibrom application. Since grouse exodus from the Mud Creek study unit was underway at the time of spraying, it is probable that the six remaining adult males had already departed, along with many yearling males and females and young.

Postspray Studies

Searches for grouse immediately postspray were much less productive than for the prespray period, primarily as a result of grouse egress (see Table 2). Observations included 14 sightings of the 10 territorial males present during spraying and no re-observations of yearling males. The last male observation was 20 days postspray.

Only six marked females, including the two instrumented hens, were observed following spraying. All six had broods. Seven re-observations of the four banded hens were made. The last banded female was observed 26 days postspray. One of these four hens was taken by a hunter 10½ weeks postspray in the Mud Creek drainage. The two instrumented females were each followed for 1 week after spraying; 25 postspray relocations were obtained, including 8 visual re-observations and 1 recapture (10 hours postspray). Both instrumented hens were shot on July 22, following unsuccessful recapture attempts. All re-observations of these six brood hens were within the spray boundary, and no indication of unusual chick mortality was noted.

Several birds exposed to Dibrom were approached for capture with a noose-pole. Two adults (one female and one male) were captured and examined at postspray intervals of 10 hours and 2 days, respectively. All birds pursued appeared to have normal coordination and escape behavior.

Observations of marked grouse during the first breeding season after spraying provided a further check of grouse survival on the Dibrom treatment area. Blue grouse banded in 1965 and re-observed in 1966 included 13 of 15 territorial males, 3 of 7 yearling males and 8 of 14 females (excluding the two collected and one hunter-killed in 1965). These are minimal figures since some birds, especially females and yearling males, may have survived and not returned to the relatively small study unit.

Male blue grouse banded on untreated areas in 1965, and re-observed in 1966 included 7 of 11 on the Black-Basin Creek study unit, and 11 of 16 on the Skalkaho study unit.

Dibrom was eliminated as a candidate spruce budworm insecticide by the U. S. Forest Service following the 1965 field trials. Blue grouse field studies with this chemical were terminated after survival checks of territorial males on the Mud Creek study unit in the spring of 1966.

Zectran Evaluations — 1965

Zectran (4-dimethylamino - 3,5-xylyl methylcarbamate) is a non-persistent carboxylic acid ester compound of the carbamate group. Zectran inhibits cholinesterase activity and has high acute oral toxicity to birds (Sherman *et al.* 1967) and mammals (Lang and Miskus 1967). Fatally poisoned mice died an average of 40 minutes after ingestion of Zectran (Lang and Miskus 1967). Moore (1966a) reports little or no dermal absorption of Zectran, and since it degrades rapidly in nature, chronic toxicity and hazard from sub-lethal doses are low. Its characteristics are such that any direct effects on bird life following forest spraying would be expected within a matter of a few hours or days after application.

Prespray Studies

Blue grouse banded on the 240-acre Tough Creek study unit prior to Zectran application included 8 of 11 territorial males, 2 yearling males and 7 females.

Eighty-one prespray observations were made of the 11 adult males on the Zectran treatment area. Neither of the yearling males and only two marked females were re-observed prior to Zectran application. One female, captured on May 13 and re-observed on June 23, was recaptured as a brood hen on July 2 and radio-equipped. The second female was broodless and was captured and radio-equipped on July 6. These two females provided 23 prespray relocations, including four visual sightings. The instrumented brood hen moved outside the Zectran treatment area 7 days prior to spraying. The instrumented broodless hen remained within the spray boundary.

Spray Application

A single helicopter applied Zectran to 1,080 acres of the Tough Creek drainage at the rate of 0.15 pounds per acre. The formulation consisted of technical grade Zectran dissolved in methylene chloride to obtain a 24 percent concentrate. One part of this solution was mixed with nine parts of cycle oil as a carrier. Zectran was applied to the 240-acre grouse study unit on July 11 (0615-0830) and July 12 (1830-1850), 1965. Spray cards indicated only light Zectran coverage of the upper ridgetop within the grouse study unit on July 11, and a second application was made there July 12. Despite the second application, the upper ridgetop received the lightest deposits of the entire grouse study unit.

Postspray Studies

The late date of the Zectran application corresponded with territory abandonment by males and decreased grouse activity on this study unit. By early July, rapidly desiccating vegetation on the open south slopes of Tough Creek greatly decreased the attractiveness of this area to blue grouse. Only 4 of the 11 adult male blue grouse located on this study unit were observed to be present at the time of Zectran application. The signal from the instrumented broodless hen was monitored almost constantly throughout the day of spraying. A brood hen located and intermittently observed on spray day was noosed and banded 9 hours after Zectran application, and one of the two chicks with her was collected.

Each of the four males present when Zectran was applied was observed only once following spraying, three (including one recapture) within 6 hours of spraying. The fourth was seen 10 days following spraying. Neither banded yearling male was observed following spraying.

The brood hen instrumented on Tough Creek was 1/8-mile outside the spray boundary when Zectran was applied. Because of doubtful exposure to Zectran, she was collected 14 hours after final Zectran application and the transmitter was retrieved for use on grouse in the Dibrom area.

Immediate postspray observations were obtained from only three marked female blue grouse exposed to Zectran in 1965. The instrumented broodless hen remained in an area of about 10 acres within the Zectran treatment area from July 8 to 16. From July 17 to 19 she moved down one-half mile to the mouth of Tough Creek. Following this she moved about 2 miles farther, and 1,000 to 1,500 feet higher, into the Cone Creek drainage. The signal from her transmitter was last heard from this area on August 24, 1965. Each of the other females observed following spraying was seen only once. A broodless hen marked within the Zectran treatment area on June 30 and the brood hen (and one chick) marked on spray day were both re-observed near the instrumented broodless hen three days postspray.

Another brood hen and four young were captured within the Zectran treatment area of lower Tough Creek on August 5, 1965. The spray exposure history of these birds was unknown.

Five of the eight territorial males banded on the 1965 Zectran treatment area survived to the following breeding season. Neither of the yearling males banded in 1965 was re-observed in 1966. Only two of the seven (minus one collected) females marked within the 1965 Zectran treatment area were known to have survived. Included was one of the three known to have been exposed to Zectran. However, the Tough Creek study unit received less intensive study during the 1966 brood season, when females are easiest to observe. In addition, survival of females and yearling males is difficult to determine on such small areas, since they have less fidelity than territorial males in returning to a specific breeding area. Though fragmentary, the evidence obtained during the 1965 field tests indicated no detrimental effects of Zectran on the small number of blue grouse exposed. More intensive field tests of Zectran and forest grouse were recommended for 1966.

Zectran Evaluations — 1966-67

Because of the number of Zectran treatment areas, the 1966-67 data will be presented by grouse study unit. Trapper Creek grouse study units were included in an operational spray test encompassing nearly 4,000 acres. The Mud Creek study unit served as a special test site in 1966, receiving multiple applications of Zectran solely for the purpose of the grouse studies.

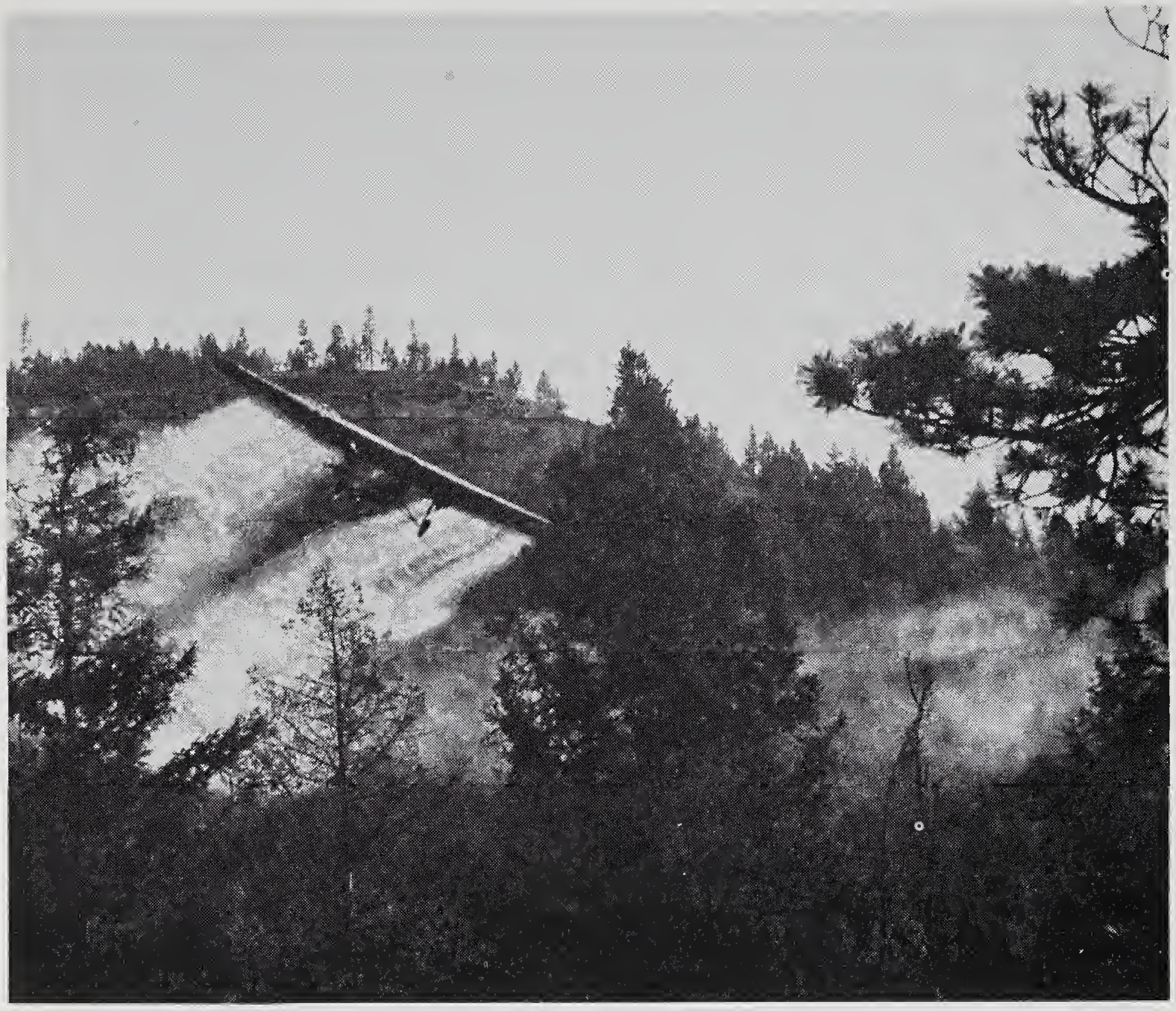


Figure 7. Ford Tri-motor spraying a single application of Zectran for spruce budworm control experiments on Trapper Creek.

Prespray Studies – Trapper Creek

Fishhook. – Six females and 8 of the 11 adult males on this 210-acre study unit were banded prior to Zectran application. No yearling males were captured. Thirty prespray observations were made of the 11 adult males, but the 6 banded females were not sighted again before spraying.

Haley Chute. – Twenty-three of the 34 territorial males located on this 390-acre study unit in 1966 were captured and banded prior to Zectran application, as well as 2 yearling males and 15 females (3 females were radio-equipped).

The 34 adult males were observed 132 times prior to spraying. Neither of the yearling males was observed prior to spraying and only 6 prespray observations were obtained from 4 of the 12 banded females. The three instrumented brood hens provided 11 prespray locations.

Spray Application – Trapper Creek

Grouse study units in the 3,910-acre Trapper Creek operational spray area were sprayed on the mornings of June 30 and July 1, 3 and 4, 1966. Single applications were made by a single helicopter along streamside zones and by a Ford Tri-motor aircraft (Figure 7) on upland areas including the Fishhook and Haley Chute grouse study units. The Zectran formulation consisted of 1 part Zectran concentrate (1.5 pounds Zectran in monobutyl ether of ethylene glycol) with 9 parts deodorized kerosene, plus 2 percent fluorescent particles with bentonite to aid in their suspension. This formulation was applied at the rate of 1 gallon per acre (0.15 pounds of Zectran per acre).

Weather conditions varied considerably during the several mornings of application on the Trapper Creek area. Wind and rain interrupted the spraying sequence, and portions of the grouse study units received partial coverage on several different days. It was impossible to observe all flight paths or to maintain spray card detection stations because of the intermittent sequence of Zectran application on the large area of this operational test.

Postspray Studies – Trapper Creek

Fishhook. – Exodus of male grouse from territories was apparently well under way on the Fishhook study unit at the time of Zectran application. Only two of the adult males were known to be present during Zectran application. Each was observed only once following spraying (1 and 11 days postspray).

A total of four postspray observations was made of two of the six females banded prior to treatment. Each was accompanied by a brood, and two of three and two of four members of their broods were captured for examination, then banded and released.

Six of eight territorial males banded on the Fishhook study unit in 1966 survived to the 1967 breeding season. Three of the six females banded prior to spraying in 1966 were re-observed in 1967, including one of the two for which postspray observations were obtained in 1966.

Haley Chute. – Abandonment of territories was also well under way on this study unit at the time of spray application. Six of the 34 males on this study unit were observed a total of seven times during the several days of Zectran application, but only one male was observed after spraying. This male was observed 9 days postspray on the Fishhook study unit 1¼ miles southwest of his territory. The 2 yearling males and 12 females banded prior to spraying were not re-observed during, or following spraying in 1966. The 3 instrumented brood hens provided 11 locations during and 31 locations following the completion of spraying. They remained within the spray boundary for 7, 10 and 19 days postspray before dispersal or transmitter retrieval. One of these instrumented females hatched three chicks, and was exposed to Zectran on July 1. She remained within the sprayed area until July 20 when recaptured for dosing (see pages 34-35).

Eighteen of the 23 adult males banded on this study unit in 1966 were re-observed during the 1967 breeding season. Only 4 of the 15 females (minus 2 collected) were re-observed during 1967, including only one known to have been exposed to the 1966 Zectran application. This single female is the instrumented hen mentioned above, and discussed in more detail later.

Prespray Studies – Mud Creek

Three more territorial males were present on the Mud Creek study unit in 1966 than in 1965, making a total of 19. Two were added by altering the study unit boundary slightly, while the third established a new territory in 1966 after being banded as a yearling in 1965. Seventeen of the 19 males on this 320-acre study unit (Figure 8) were banded, most of them during the 1965 Dibrom evaluation. Prespray observations of these 19 males totaled 129. Two of these males were instrumented and provided an additional 60 prespray locations. No yearling males were banded on Mud Creek in 1966.

Nine 1966 prespray observations were obtained of six female blue grouse banded in 1965 and one banded earlier in 1966. Six 1965-banded females were recaptured and radio-equipped in 1966, including four which had been re-observed earlier in 1966. Four other females initially captured in 1966 were also instrumented. These 10 instrumented females (3 non-breeders or unsuccessful nesters and 7 brood hens) provided 213 prespray locations. One transmitter was removed and another malfunctioned prior to spraying.

The movements of two instrumented females were confined to less than 10 acres for 6 and 7 days before incubation began, and until it was terminated. One nesting hen successfully completed incubation, while the other's nest was destroyed 10 days after incubation began. This hen used an area of 115 acres for 12 days following the destruction of her nest. Two other non-breeding or unsuccessfully nesting hens instrumented and tracked for 25 and 36 days used areas of approximately 75 and 125 acres, respectively.

Spray Application – Mud Creek

This special study unit received five consecutive Zectran applications by a single helicopter (Figure 9) on June 25 and 26, 1966. June 25 weather was clear and cold with freezing temperatures before sunrise. Wind gusts hampered application on lower ridgetop portions of the study unit. Weather conditions were more favorable on June 26, being clear and calm until after 9:00 a.m. when spraying was completed.

Forest Service records show that 260 gallons of Zectran formulation were applied to the Mud Creek study plot June 25, and 540 gallons on June 26. All flight paths were observed and recorded on an aerial photograph. This, together with spray cards, indicated spray coverage of the entire 320-acre area.

With the five consecutive swaths at 0.15 pounds per acre, the anticipated coverage was 0.75 pounds per acre, but on the basis of gallons sprayed it was only half the cumulative rate expected, or 0.375 pounds per acre. Presumably there was a misunderstanding of the size of the study area.

Postspray Studies – Mud Creek

Zectran was applied on this study unit before most male grouse abandoned their territories. Twelve of the 19 territorial males were known to be exposed to Zectran spraying. Ten of these males were observed a total of 17 times during or following Zectran application, and the 2 instrumented males added an additional 41 locations during or after spraying. The Zectran exposure of the other seven males is unknown. Though initial egress of breeding males from Mud Creek had apparently begun by the week of spraying, seven males were still present on July 1. One instrumented male remained on the study unit until July 6 when he was shot and the transmitter removed. The second male remained until July 18 when loss of telemetry signals indicated either transmitter failure or departure from the area.

One female banded earlier in 1966 was re-observed on the first day of spray-

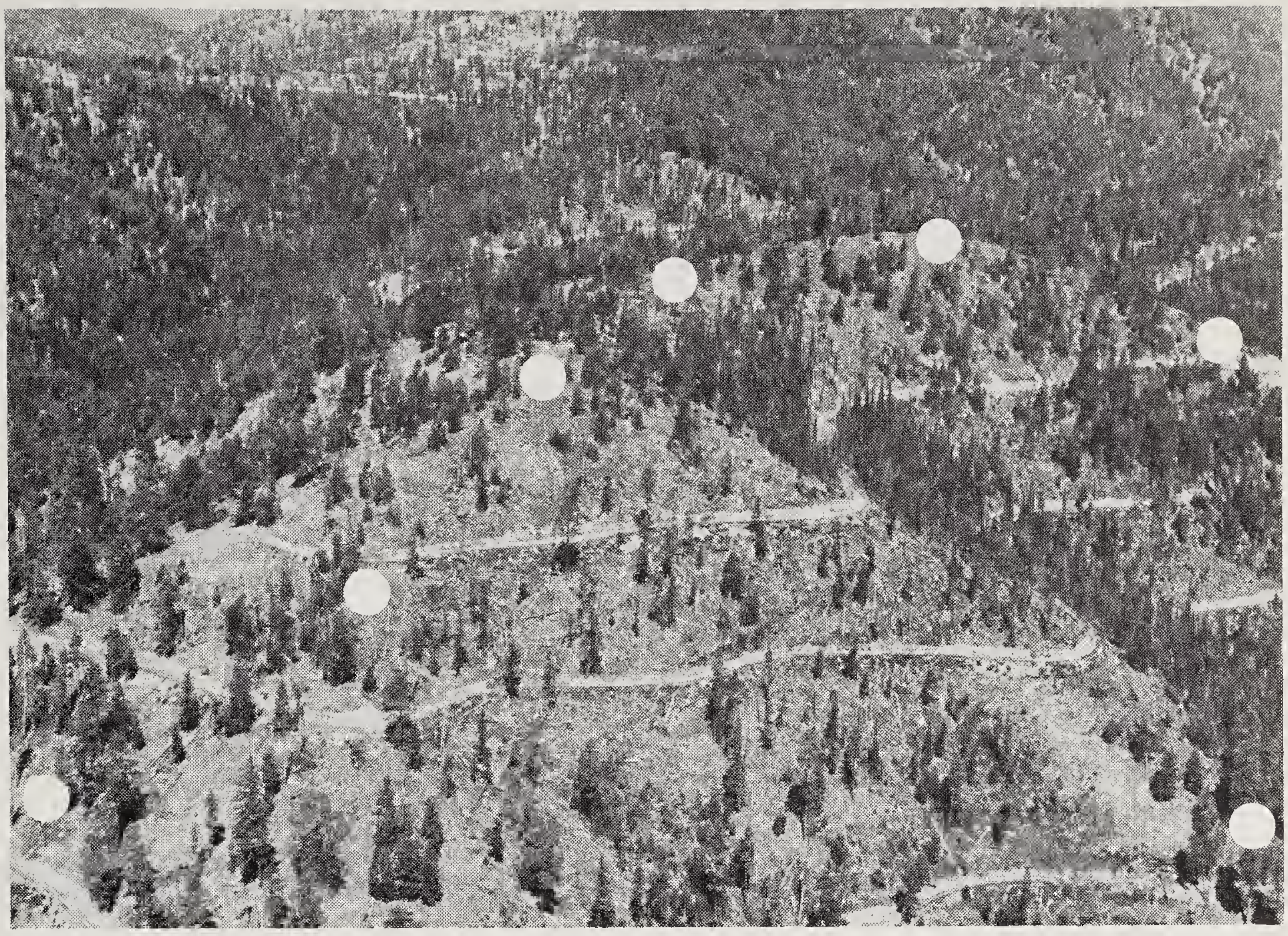


Figure 8. Aerial view of the Mud Creek blue grouse study unit. Seventeen of the 19 male blue grouse holding territories on this ridge were banded prior to multiple Zectran applications in 1966. Seven of the territories are shown by white circles. Dibrom was sprayed on this area in 1965 and Zectran in 1966.

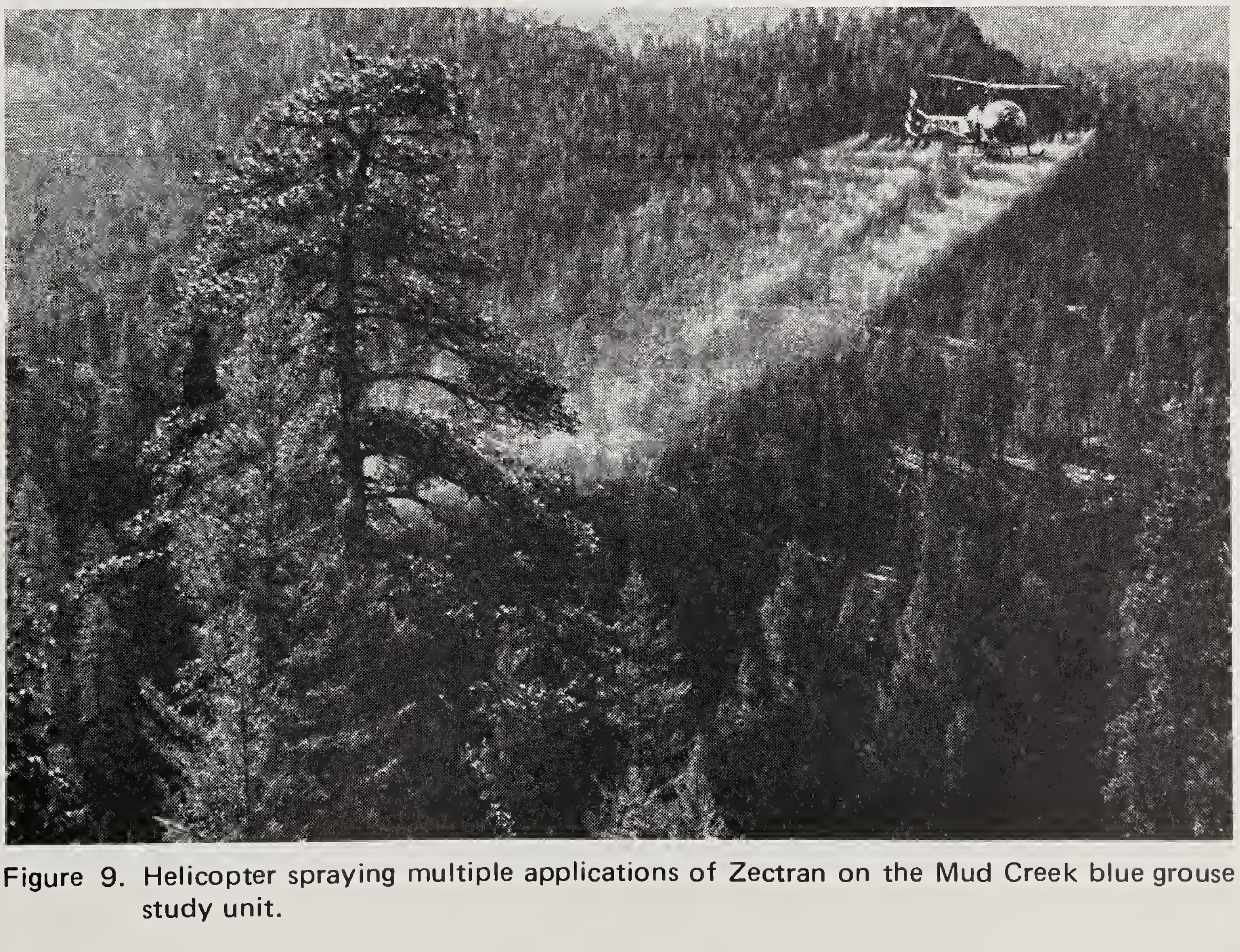


Figure 9. Helicopter spraying multiple applications of Zectran on the Mud Creek blue grouse study unit.

ing and not again. Single postspray observations were made of two 1965-banded females, one of which was also observed once prior to spraying. She was reported shot by a hunter later that fall. Two females with unknown spray exposure histories were caught and banded following spraying, but neither was seen again in 1966. Eight instrumented females (seven with broods) were present on Mud Creek at the time of Zectran application. These 8 birds provided 32 and 302 locations on the 2 days of spraying and postspray, respectively.

The seven broods remained within the sprayed area for 1 to 37 days prior to dispersal. Brood ranges (including both pre- and postspray periods) of these seven broods varied from 50 to 180 acres prior to dispersal, averaging 112 acres. The broodless hen was collected for food habit analysis 1 day postspray. One instrumented brood hen left the spray area on the second day after application and moved over 5 miles within 1 week. The six other instrumented brood hens remained on the Zectran treated area from 22 to 37 days after spraying (Appendix Figures 1 and 2).

Eleven of the 17 banded males present on the Mud Creek study unit in 1966 were known to have survived to the 1967 breeding season, including 7 of the 12 (minus 1 collected in 1966) known to have been exposed to Zectran. An eighth male survived to the fall of 1966 when taken by a hunter. Five of the 14 females on the Mud Creek study unit prior to spraying in 1966 were collected for transmitter retrieval at the termination of the studies. Of the nine remaining females, one was taken by a hunter later that fall, and only two were observed a total of six times the following year. One of these two had an unknown spray exposure history, while the other had carried a transmitter for 42 days in 1966, including 24 days within the spray boundary following spraying. One of the two females banded following 1966 spraying was re-observed three times in 1967, but her spray exposure history was unknown.

Two of the blue grouse (one male and one female) which escaped from the pen atop Mud Creek in 1966 were located on this study unit in 1967. The male was territorial in 1967, while the female was an unsuccessful nester.

Brood survival. – The 1966 Zectran spraying occurred when most blue grouse chicks were less than 2 weeks of age. The precocial ground-dwelling and insectivorous habits of grouse chicks presented an opportunity for both oral and dermal contact with a pesticide aerially sprayed in their habitat. However, natural early chick mortality (Zwickel and Bendell 1967) and the difficulty of accurately counting young broods (Wing *et al.* 1944 and Boag 1966) precluded a clear-cut assessment of chick survival in relation to Zectran applications.

Concerted efforts to obtain complete counts of broods less than 2 to 3 weeks old produced erratic results. Counts became more uniform after chicks reached this age and were capable of strong flight. Brood count data are shown in Table 3. At least one pre- and postspray brood count (apparently complete) was obtained for each of nine instrumented brood hens. The tenth instrumented hen hatched three eggs during spraying. The last prespray brood count for nine instrumented hens resulted in a total of 19 chicks. The first postspray count (1 day postspray in all but one case) of these same broods gave a total of 12 chicks, a reduction of 37 percent from the prespray count. However, the maximum brood sizes observed in later postspray counts gave a combined total of 23 chicks, exceeding the prespray total. The higher postspray count is probably due to better observational conditions resulting from vegetation desiccation, and increased size and flight capabilities of the chicks.

These brood count data indicate the degree of inherent error in counting young broods. Chicks are capable of short flights by 2 weeks of age, but consecutive flushing counts indicated that some brood members evidently chose to hide rather than fly when disturbed. The logistics of manpower and equipment precluded an experimental design by which the survival of significant numbers of telemetered broods could have been compared on sprayed and non-sprayed areas.

Six broods (A, B, C, E, F and G, Table 3) were known to remain on the multiple-sprayed Mud Creek unit during the immediate postspray period when potential Zectran toxicity hazards would be the highest. The repeated flush counts of telemetered broods before and after Zectran exposure provided positive indications of chick survival and circumstantial evidence of chick loss in one brood shortly after spraying.

Brood A was observed to have at least four chicks 4 days before spraying; 1 day after spraying no chicks were located, and three subsequent observations showed only one chick present. Whether chick loss in this brood was merely coincidental to spray application or a direct effect of it is not clear. Zwickel and Bendell (1967) report that at least one-half of blue grouse chicks die at young ages with most of the loss during their first 2 weeks. All chicks observed at various postspray intervals on Mud Creek and Trapper Creek appeared to have normal flying coordination and escape behavior. Positive survival was indicated for the broods exposed to Zectran on Trapper Creek (brood hens H, J, K and six chicks). Postspray changes in sizes of broods B, C, D, E, F and G are probably within the range of natural attrition rates and the limitations of the counting procedure.

Male Breeding Densities and Survival Rates on Sprayed and Unsprayed Areas

Blue grouse males are known to have a high fidelity to their breeding areas, and those that do not return from wintering areas are assumed to be dead (Boag 1966 and Bendell and Elliott 1967). The total number of territorial male blue grouse on an area is commonly used as an index of population density. Natural attrition rates of blue grouse are calculated by the year-to-year survival of banded territorial males. It is expected that induced mortality (as by a pesticide) could be reflected in changes in male breeding densities or survival rates to the following year. Territorial male removal experiments (shooting) by Bendell and Elliott (1967:43) indicated virtually no replacement by new adult males the same year. Replacement was primarily by yearling males that frequented breeding areas but seldom held territories due to dominance by older males. Forest spraying in late June could be expected to expose many territorial males and some of their potential replacements. The extent of adverse effects of phosphamidon on grouse following 1963 spruce budworm control trials in Montana (Finley 1965) might have been quantitatively evaluated if territorial blue grouse males could have been censused and banded before spraying.

The numbers of territorial males on sprayed and unsprayed study units during

TABLE 3. NUMBER OF CHICKS OBSERVED IN BROODS OF TEN RADIO-EQUIPPED BLUE GROUSE BROOD HENS (BY WEEKLY AGE OF CHICK) IN RELATION TO ZECTRAN APPLICATION IN 1966. (POSTSPRAY OBSERVATIONS ARE IN COLOR).

Age of Brood (weeks)	INDIVIDUAL BROODS[1]									
	A	B	C	D	E	F	G	H	J	K
1	7 2		8 6	2	0 2	1	1			3 0
2	4	4	4 2[2]	0 1	0[2] 3	1	4 0 1 0		1	4[3]
3	0 1 1	3	0 6 6	2	3	1	1 1 1	1	1	3
4		3	5 5	1 1	4	1	3 3	2	0[2]	
5		2	5		1[2] 0[2]	0				
6		2 1 2	5 3 4		2 3	1		2		
7					2[2] 2[2]	1			1	
7+	1		3							

[1] Four chicks hatched in Brood E, and three in Brood K. The other broods were initially observed at the age indicated. Broods A-G, Mud Creek; H-K, Trapper Creek.

[2] No attempt made to flush all chicks.

[3] One chick was about 10 days older than the rest; no other grouse were observed.

1965, 1966 and 1967 are shown in Table 4. There were no indications of unusual changes in breeding male numbers when comparing either pre- and postspray or sprayed and unsprayed populations.

The survival of adult males banded prior to spraying in 1965 and 1966 and observed 1 year later is compared to that of unsprayed males in Table 5. Comparison of survival rates of sprayed and unsprayed grouse does not indicate abnormal mortality of males on either individual or combined study units. Variations between study units are within the limitations of the methods. The annual survival rate of banded males on the Skalkaho unit has averaged 68 percent (65 of 95) from data accumulated during the 1962 to 1967 period (Schladweiler 1968). The mean annual survival from a sample of 125 banded male blue grouse in British Columbia was 72 percent (Bendell and Elliott 1967).

TABLE 4. NUMBERS OF TERRITORIAL BLUE GROUSE MALES ON STUDY UNITS DURING 1965, 1966 AND 1967.

Study Unit	Acres	Treatment (year)	NUMBER OF TERRITORIAL MALES		
			1965	1966	1967
SPRAYED:					
Mud Creek	320	Dibrom (1965)	16	17[1]	
		Zectran (1966)		19[1]	18[3]
Tough Creek	240	Zectran (1965)	11	10	
Trapper Creek-Haley Chute	390	Zectran (1966)		34	31
Fishhook	210	Zectran (1966)		11	10[3]
UNSPRAYED:					
Black-Basin Creeks	290		14	12[1]	12
Skalkaho[2]	457		35	38	36

[1] A slight change in boundary, but not area, included two additional males in the 1966 Mud Creek treatment area, and two less in the Black-Basin Creeks control area.

[2] DDT in 1963.

[3] One removed by shooting after spraying in 1966.

Limitations of these data should be noted. Except for the Mud Creek unit, spray applications occurred after many territorial males had begun departure from their breeding to wintering areas. The chronology of 1966 spray applications in relation to the presence (or absence) of territorial males on Mud Creek, Fishhook and Haley Chute study units is indicated in Appendix Tables 1, 2 and 3, respectively. Twelve of 19 Mud Creek males were known to be present during multiple Zectran applications. Seven of the 12 banded males positively exposed to Zectran survived to the breeding season of the following year; an eighth male survived to fall when taken by a hunter. Complete exodus of males from the Mud Creek area apparently did not occur until early July, as 7 of 17 banded males were known to be present there after July 1.

Male egress from the two Trapper Creek units evidently occurred earlier than from Mud Creek. Only 2 of 11 males on the Fishhook study unit were known to be

TABLE 5. ANNUAL SURVIVAL OF BANDED BLUE GROUSE MALES ON SPRAYED AND UNSPRAYED AREAS.

Study Unit	Treatment (year)	Number Banded Males	Number Surviving to Following Spring	Percent Survival
Tough Creek	Zectran (1965)	8	5	63
Mud Creek	Dibrom (1965)	15	13	87
	Zectran (1966)	17	11[1, 2]	65
Trapper-Fishhook	Zectran (1966)	8	6[1]	75
Trapper-Haley Chute	Zectran (1966)	23	18	78
TOTAL (Insecticide Exposure)		71	53	75
Black-Basin Creeks	None (1965)	11	7[2]	64
Black-Basin Creeks	None (1966)	11	7[3]	64[3]
Skalkaho	None (1965)	16	11	69
Skalkaho	None (1966)	20	14	70
TOTAL (Unsprayed)		58	39	67

[1] Plus one collected after the 1966 Zectran application.

[2] Plus one surviving to the subsequent fall hunting season.

[3] Incomplete search in 1967.

present during Zectran applications (June 30-July 4). Each male was observed once following spraying (1 and 11 days postspray). Only 6 of 34 territorial males on the Haley Chute unit were observed during the spray application period. Only one of these males was observed after completion of spraying.

The 1966 Zectran test on Mud Creek was considered more rigorous because the grouse there were exposed to consecutive applications (five repeated swaths) of Zectran within a 29-hour period. Trapper Creek grouse were exposed to single swaths of Zectran applied intermittently with some overlap during a 5-day application period. Higher toxicity could be expected during the repeated applications and shorter time interval of spraying on Mud Creek.

Blue Grouse Summer Food Habits and Zectran Residues

Blue grouse eat a variety of plant and animal material during the early summer. July and August blue grouse food habit studies in the Skalkaho area following 1963 DDT spraying (Mussehl and Finley 1967) showed that the crops of 35 juveniles contained 76.5 percent (by volume) animal material; crops of juveniles under 7 weeks of age contained 75 to 90 percent insects, 63 percent of which were grasshoppers; and crops of 22 adults contained 26.9 percent insects, 26.3 percent berries, 34.6 percent forbs, 10.8 percent conifer needles and 1.4 percent miscellaneous plant material.

Nine blue grouse (seven adults and two juveniles) were collected from Mud Creek and Trapper Creek areas within 10 days after spraying in 1966. The crops of one adult and one juvenile were empty, while the second juvenile contained only traces of Hymenoptera and unidentified pupae and plant material. Plant material was the major content in the six remaining adult crops. *Ceanothus, Tragopogon* and *Fragaria* species comprised 100, 99 and 63 percent (by volume) respectively, of three crops. *Shepherdia, Polygonum* and *Vaccinium* species constituted 100 and 26 percent of two crops, 99 percent of one crop and 86 percent of one crop, respectively. One crop obtained 1 day after spraying contained four spruce budworm larvae (9 percent of total crop contents). Mussehl and Finley (1967) reported spruce budworm larvae in over half of the blue grouse crops obtained within 10 days after DDT spraying.

Zectran is degraded more rapidly than DDT, which persists on forest vegetation in significant amounts for months (Casebeer 1965, Mussehl and Finley 1967). Subacute toxicity tests (Sherman *et al.* 1967) indicated that 200 ppm of Zectran mixed with feed caused no symptoms of toxicity in young cockerels, although birds receiving higher toxic levels had symptoms of poisoning. They also reported that 140 ppm of Zectran in the feed resulted in 50 percent cholinesterase inhibition in cockerel blood plasma after 1 to 2 weeks of feeding.

Residue levels and persistence of Zectran on vegetation exposed in Trapper Creek were determined and reported by Pieper and Miskus (1967), (see Table 6). Zectran residue levels on spray day ranged from 0.75 to 7.85 ppm on the six plant species sampled. Maximum residue levels are unknown; no effort was made to correlate spray card deposit assessments with residue analysis. Plant samples from the multiple-sprayed Mud Creek unit were only semi-quantitatively analyzed for Zectran (Miskus, R. P. 1968, personal communication), and though greater residues were indicated, no quantitative figures are available. All six species of vegetation analyzed for Zectran are known to be used by blue grouse for food. Zectran residue levels dropped rapidly after the first day in four of the six plants. The amount of Zectran left after 1 week appeared negligible except in *Fragaria* and *Ceanothus* species, indicating that the rate of disappearance was mediated by the plant substrate.

Field Studies: Ruffed and Spruce Grouse

Ruffed and spruce grouse were rarely encountered in the relatively open habitat of blue grouse study units. Ruffed grouse were common in the heavy cover (Figure 10) associated with drainage courses in Trapper Creek. Spruce grouse were occasionally observed in the Mud Creek and Trapper Creek areas but were not common on study units. Field studies consisted of limited banding, plus telemetry, of ruffed grouse males on Trapper Creek in 1966. Ruffed and spruce grouse were located off the study units and captured for Zectran dosing tests in 1966 and 1967.

Intensive searches during late May of 1966 located eight ruffed grouse drumming sites in the Little Trapper Creek bottom. Mirror trapping at seven of these sites (35 trap nights) resulted in the capture and marking of five adult male ruffed grouse.

One adult female spruce grouse was banded on the 1965 Dibrom treatment area 25 days postspray. Her exposure to Dibrom is doubtful. She was shot by a hunter 7 weeks later. A second adult female spruce grouse was banded on the Haley Chute study unit prior to Zectran application in 1966. No other spruce grouse were observed on study units.

TABLE 6. ZECTRAN RESIDUES FOUND ON VEGETATION AFTER PERIOD INDICATED (AFTER PIEPER AND MISKUS 1967).

Species	DAYS								WEEKS			Recovery Factor, Percent
	0	1	2	3	4	5	6	8	2	3	4	
Pseudotsuga menziesii	2.86	0.19	0.22	0.15	0.14	0.17	0.14	0.17	--	0.13	--	77
Balsamorrhiza spp.	7.85	0.47	0.33	0.28	0.94	0.82	0.94	0.13	0.22	0.04	0.00	85
Ceanothus spp.	1.29	1.56	.094	1.25	1.52	1.56	1.00	0.67	2.01	--	0.19	48
Fragaria spp.	6.25	4.17	4.58	2.19	5.73	2.71	3.10	--	0.73	0.94	0.38	48
Taraxacum spp.	2.29	0.44	0.11	0.11	0.08	0.04	0.01	0.13	0.07	--	0.00	70
Tragopogon spp.	0.75	0.56	0.29	0.06	0.04	--	0.04	0.01	0.01	--	0.11	80

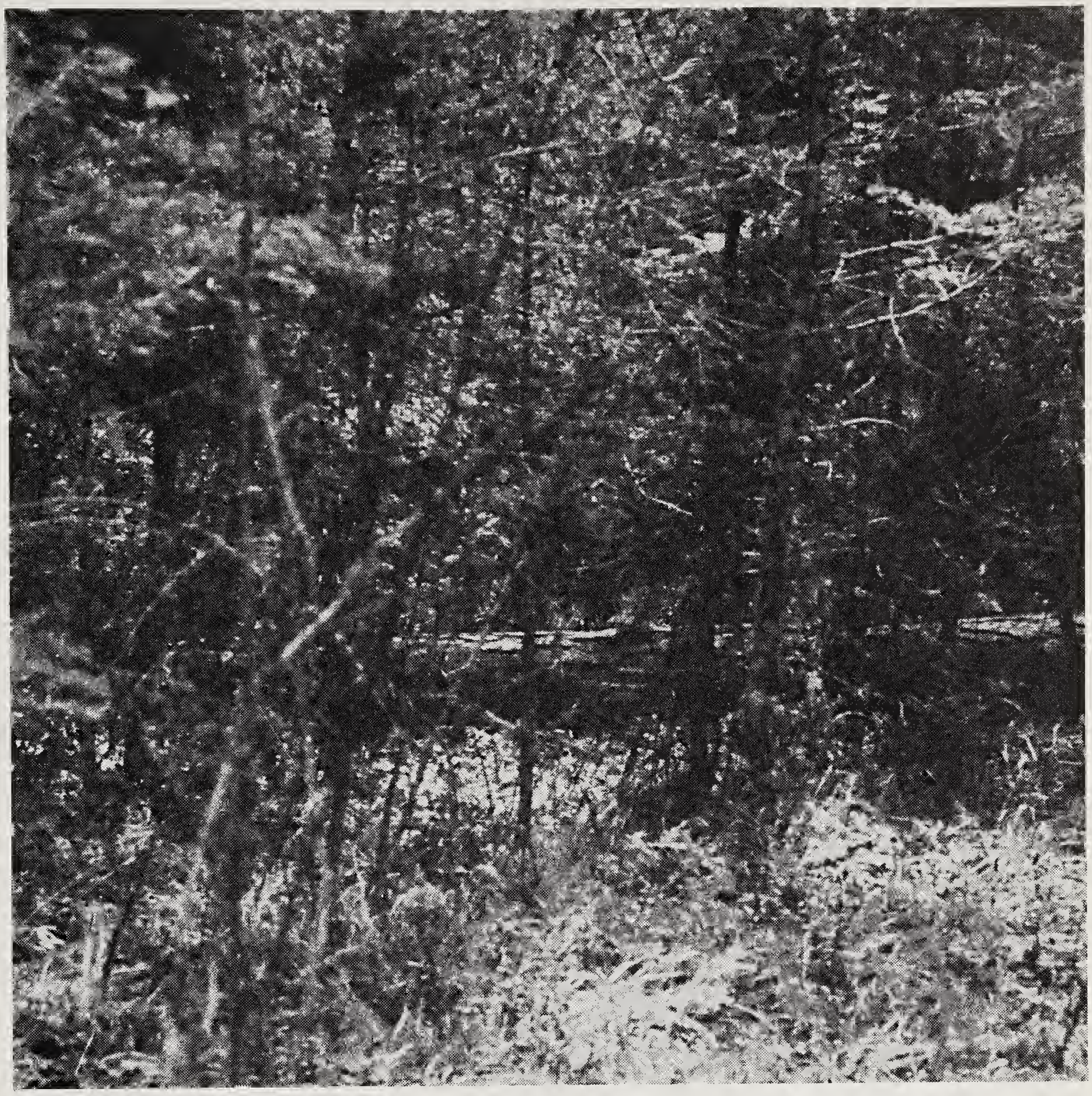


Figure 10. Ruffed grouse drumming log in heavy cover of mixed conifer-deciduous trees.

Zectran Evaluations — 1966

Two of the five ruffed grouse captured during 1966 were instrumented and tracked between May 27 and July 23. Observations were limited to these two instrumented birds. The other three banded ruffed and one banded spruce grouse were not re-observed during either the immediate pre- or postspray observation period. Telemetry provided 94 relocations (28 postspray) of these two males, including four visual observations (two postspray) and one recapture. Telemetry indicated that both instrumented males remained within the Trapper Creek spray area during pre- and postspray tracking periods. These two males utilized areas of 7½ and 8 acres during the tracking period.

Four of the five male ruffed grouse marked in the Little Trapper Creek bottom were known to have survived for varying lengths of time following Zectran spraying. Telemetry indicated that the two instrumented males survived for a least 7 and 19 days after spraying. One instrumented male was recaptured on July 23, 1966 and the transmitter removed. Radio signals from the second instrumented male ceased on July 11, 1966. This bird was taken by a hunter 15 months later with the transmitter still intact (except for a broken antenna). Two of the other three banded ruffed grouse males were known to survive the Zectran tests. One was shot by a hunter 4 months later, and one was recaptured 12 months later.

Use of Telemetry in Forest Grouse-Insecticide Evaluations

Spruce budworm spraying in late June and early July occurred when blue grouse became increasingly difficult to observe because of decreased courtship activity, the secretive behavior of nesting and brood hens and the development of ground cover (Figure 11). Conventional grouse observing techniques offered only

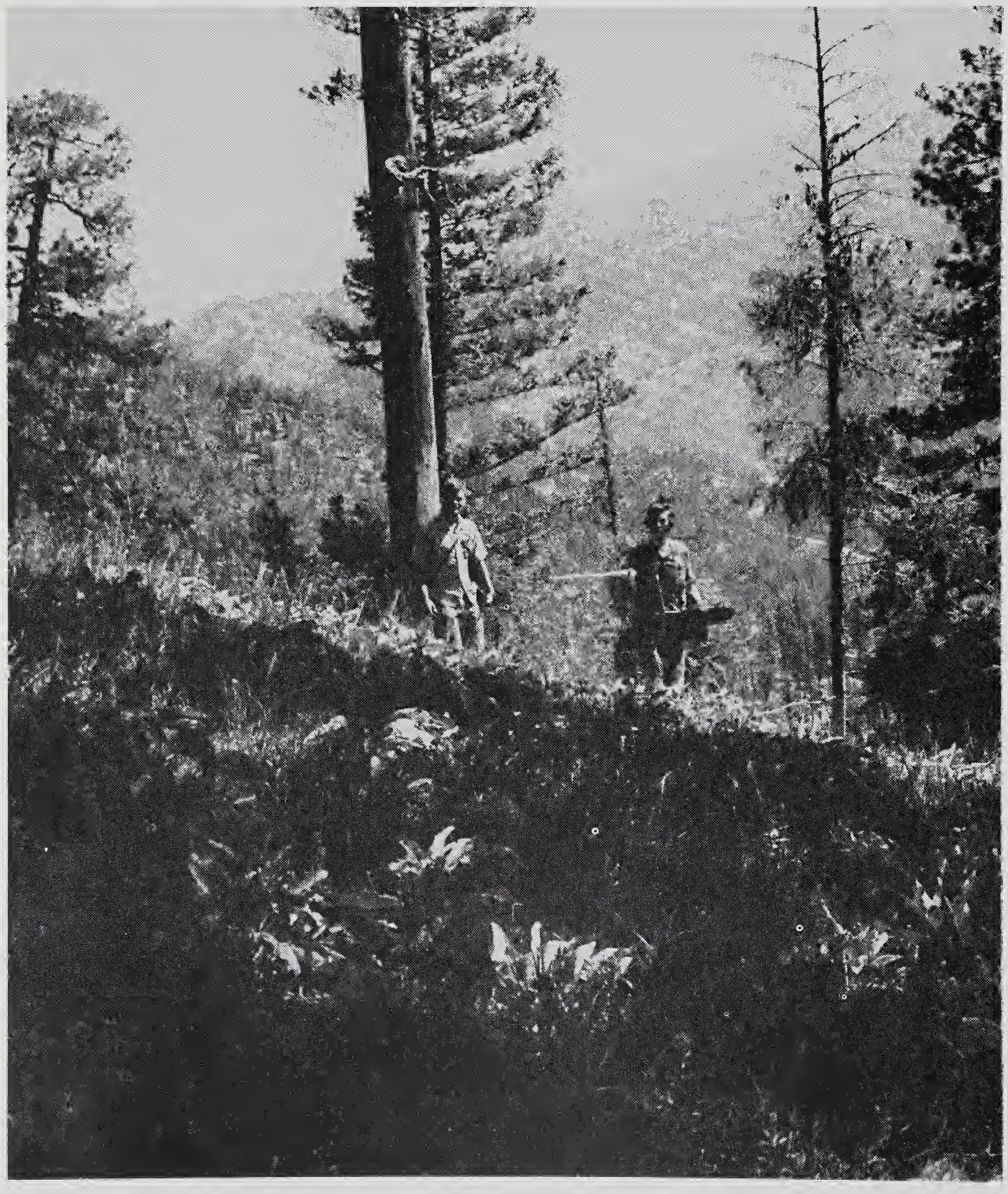


Figure 11. Radio telemetry provided the ability to readily locate blue grouse for postspray survival checks despite the lush, herbaceous ground cover.

limited chances of observing specific wild grouse at pre- and postspray intervals. The limited use of telemetry in 1965 showed the potential to overcome this problem. Telemetry provided several advantages: tracking grouse movements in relation to spray boundaries, locating casualties and detecting sublethal effects on grouse activities or behavior. Use of grouse telemetry was expanded in 1966 and was a major technique used in the evaluation of Zectran.

Telemetry vs. conventional methods. – The value of telemetry as a supplement to conventional grouse study methods during 1966 is indicated in Table 7. During 98 days of pre- and postspray field work two telemetry observers located 15 instrumented blue grouse a total of 699 times, including 96 visual observations and 7 recaptures. During the same period, two to three observers identified 47 banded blue grouse 87 times. All observations were made on study units where the density of blue grouse was roughly one territorial male per 15 acres, and more than half of the adult blue grouse were individually banded. Telemetry was a particularly important supplement to conventional grouse marking methods during immediate pre- and postspray periods. Between June 21 and July 18, 1966, only 15 (of 75 to 80 potentially observable) banded blue grouse were identified (17 times) by the four-man field crew. During the same period 326 relocations of 13 instrumented blue grouse were obtained by the two telemetry observers of the four-man crew.

Telemetry was of particular value in studying survival, behavior and movements of female grouse and broods. In addition to the 4 and 13 females instrumented in 1965 and 1966, respectively, 24 and 18 other females were banded prespray on the various treatment areas during the same years. Postspray observations were obtained from only six and three of these banded females in 1965 and 1966, respectively.

TABLE 7. REOBSERVATIONS OF CONVENTIONALLY MARKED BLUE GROUSE COMPARED WITH RADIO TELEMETRY RELOCATIONS BY 2-WEEK PERIODS DURING 1966.

	CONVENTIONAL MARKING		RADIO TELEMETRY	
Period	Identifications	Birds Observed[1]	Relocations	Birds Instrumented[1]
May 10-23	43	27	53	5
May 24-June 6	16	13	51	5
June 7-20	6	5	105	12
June 21-July 4	11	10	198	13
July 5-18	6	5	128	12
July 19-Aug. 1	4	4	117	8
Aug. 2-15	1	1	47	5
TOTALS	87	47	699[2]	15

[1] Numerous duplications occur between time periods.

[2] Includes 96 visual observations and 7 recaptures.

The timing and extent of dispersal of the seven instrumented brood hens from the Mud Creek area are shown in Figure 12. This extensive dispersal from

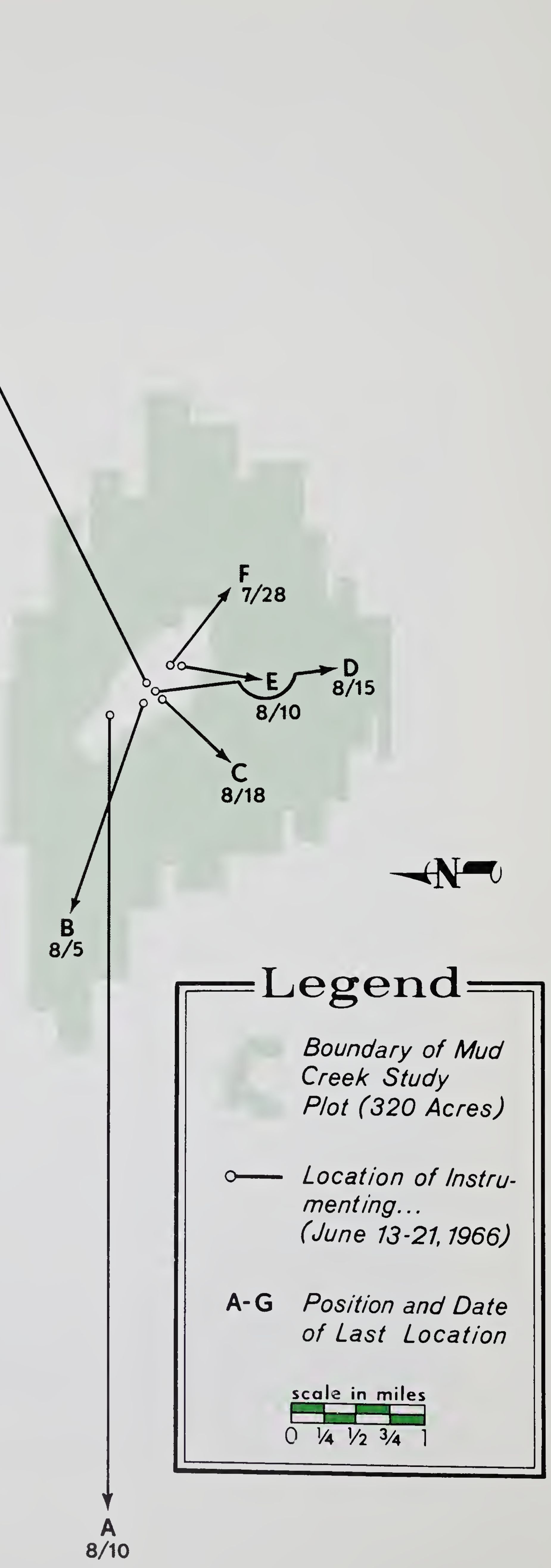

G
7/6
F
7/28
D
8/15
E
8/10
C
8/18
B
8/5
A
8/10
N
Legend
Boundary of Mud Creek Study Plot (320 Acres)
Location of Instrumenting... (June 13-21, 1966)
A-G
Position and Date of Last Location
scale in miles
0
¼
½
¾
1

Figure 12. Timing and extent of dispersal of instrumented blue grouse brood hens from the Mud Creek Study Unit.

summer brood range shows that blue grouse broods exposed on relatively small spray areas can be expected to be re-distributed over much larger areas within a month or two after spraying. Such extensive dispersal indicates the limitations of comparing blue grouse productivity indices (age ratios) between sprayed and unsprayed areas as done by Hoffman *et al.* (1958) and Mussehl and Finley (1967).

Casualty detection. – The ability to locate pesticide casualties by telemetry was not directly demonstrated, since all instrumented birds survived the field tests. Radio-tracking females to their nest sites was the closest simulation of the finding of casualties. The successful use of radio telemetry for locating pesticide casualties has been demonstrated by McEwen and Brown (1966) during experiments with sharp-tailed grouse *(Pedioecetes phasianellus)* given lethal, oral dosages of dieldrin or malathion.

This improved capability is of prime importance in view of the limitations of casualty detection by conventional searching reported by Rosene and Lay (1963). Telemetry provided positive evidence that adult blue grouse exposed to single or multiple aerial applications of Dibrom or Zectran survived within sprayed areas for up to 37 days after spraying.

Detection of sublethal effects. – Observations of instrumented blue grouse orally dosed during pen studies indicated that the influence of grouse movements on the whip antenna made gross signs of Zectran poisoning electronically detectable. Within an hour after dosing, Zectran symptoms progressed from lethargy to unsteadiness, head-wobbling and violent wing-flapping spasms. Such gross behavior changes were readily indicated by corresponding radio signal changes. McEwen and Brown (1966) noted head-nodding, convulsions, and respiration changes in insecticide-dosed sharptails equipped with the same type of transmitters.

Nine instrumented blue grouse (seven females and two males) were monitored for activity and respiration changes before and after spraying on Mud Creek in 1966. A rotational antenna (20 feet high) located on a ridge top allowed signal reception from most of the nine grouse at any given time.

Gross activity monitoring. – A method modified from Jenkins (1961) was used to quantify gross activity patterns of instrumented grouse before and after exposure to Zectran in 1966. Grouse activity (moving or steady) was electronically detected for each of two, 10-second periods each minute. Recording periods were usually 10 minutes in length. It was postulated that changes in grouse behavior due to potential Zectran poisoning might be reflected in the proportion of steady and active signals from instrumented grouse exposed to spraying. Nighttime activity patterns appeared promising to monitor as roosting grouse are apparently inactive. It was conceivable that an instrumented blue grouse might receive sufficient Zectran during a late afternoon feeding period to lose coordination during its evening roosting period. During the prespray nighttime sampling period, 98 percent of electronic signals received indicated grouse were "steady" or inactive (Table 8). Relative activity periods of instrumented grouse monitored the night after Zectran exposure indicated no significant change in activity patterns. From the standpoint of Zectran evaluation these data are very limited since they represent the activities of only nine blue grouse during a short postspray time period. This method of determining gross changes in grouse activity was further limited to periods of relative calm when the whip antenna was not disturbed by air movements.

Respiration. – Increased respiration rates were noted among penned birds that were orally dosed with Zectran. Respiration rates are electronically detectable from instrumented birds that are inactive and not influenced by wind. Respiration rates of night-roosting, instrumented grouse on Mud Creek were monitored on prespray nights and between 9:00 p.m. and 1:00 a.m. the first and second nights after spraying. The average prespray night respiration rate of 19.8/minute (during 37, 10-second periods) does not appear to differ significantly from the postspray average of 18.2/minute (38, 10-second periods).

TABLE 8. SUMMARY OF TIMED ACTIVITIES OF RADIO-EQUIPPED BLUE GROUSE.

				ACTIVITY			
				Steady		Movement	
Period	Time	Recording Periods	Seconds	Seconds	Percent	Seconds	Percent
Prespray	Daylight[1]	35	7400	5270	71.22	2130	28.78
	Night	11	2000	1962	98.10	38	1.90
Postspray	Daylight	11	2200	1362	61.91	838	38.09
	Night	17	3700	3557	96.13	143	3.87

[1] Daylight hours were arbitrarily chosen to include the time from 5:00 a.m. to 9:00 p.m. (Mountain Standard time).

Unusual changes in respiration or activity were not noted during our relatively short postspray experiments with instrumented grouse. The experiments were not intensive enough to conclude that subtle physiological changes recognizable by this method had not occurred in Zectran-exposed grouse. Listening fatigue greatly limited the duration that the two telemetry observers could effectively operate. Though a thorough evaluation of Zectran and grouse was not provided, this technique shows promise for electronically detecting subtle behavior or physiological changes in wildlife exposed to insecticides.

There were no indications that instrumentation adversely affected any of the instrumented birds. Individual grouse carried operational transmitters up to 90 days without indications of deviations from normal behavior (other than occasional increased wariness following repeated human disturbance). Eleven females with young broods were instrumented. All returned to their broods within a short time after release. Two females instrumented in early May began incubation 7 and 8 days later. Three females netted on or near their nests resumed incubating and successfully hatched their eggs. Both ruffed grouse males were heard drumming within 2 days after instrumenting. One instrumented blue grouse male was observed displaying on several occasions. A second instrumented male was not seen in courtship display, but this may have been due to the late date of instrumentation (June 18) when display activity was subdued. Sixteen instrumented grouse (including one ruffed grouse that carried a transmitter for 15 months) were examined at least once after instrumentation; no signs of injury, harness abrasion or abnormal body weight were evident.

Monitoring Zectran-dosed brood hens. – Symptoms of insecticide poisoning were not detected in grouse monitored after aerial application of Zectran. After spraying (July 20, 1966) an instrumented brood hen (No. 243) was recaptured on Trapper Creek, orally dosed with 10.66 mg/kg of Zectran and released to her brood. Her signal was then monitored from a distance of about 200 yards. Within 32 minutes after dosing she failed to respond to distress calls of her chicks (the female's response to these calls is electronically detectable). The first electronic indication of symptoms occurred at 41 minutes after dosing. When located 54 minutes after dosing, the hen was prostrate and unable to rise. She remained in this condition and had not improved within the next 2 hours, after which observation ceased. She made six unsuccessful attempts to stand during the observation period. Eight hours after dosing the hen had recovered and behaved normally, though contact with her brood was lost. Three days after dosing she was recaptured and the transmitter removed. Intensive searches and observation indicated she had not regrouped her brood.

A similar experiment was conducted in 1967, and by coincidence with the same brood hen dosed the previous year. The first 1967 capture of female 243 was on June 25, 1 day after her nest was discovered. The 1967 nest was located about 45 yards from her 1966 nest site. When captured, three of seven eggs in the nest were freshly hatched, three were pipped and one showed no sign of hatching. Six of the seven eggs successfully hatched, and the female and chicks left the nest on June 25. At least four chicks were with the hen 1 week later, and a minimum of three, 2 weeks after hatching.

On July 9, 1967, female 243 was recaptured, orally dosed with 10.70 mg/kg of Zectran and released to her brood. The signs of Zectran poisoning and reactions of the female after release were very similar to those observed the year before. The day after dosing this female was flushed near where she had last been observed. No chicks were found in the vicinity, and no broody behavior could be elicited from the female. The same thing was true 3 days later when she was flushed three times prior to recapture and removal of the transmitter. As in 1966, the fate of the chicks seen with her when dosed remains unknown.

The fact that this female survived and successfully reproduced the year following a near-lethal oral dose of Zectran indicates that no permanent physiological damage had resulted after the acute dosage.

The loss of chicks by this hen in two successive years following sublethal Zectran dosing suggests that, even if no direct mortality occurs from insecticide exposure, the security provided by the strong bond between hens and young could be diminished by sublethal pesticide effects.

Pen Studies

Pheasants and three species of forest grouse were subjected to chronic and acute oral dosages of Zectran to determine: 1) the relative acute oral toxicity of Zectran to these game birds, and 2) signs of poisoning induced by lethal and sublethal amounts of Zectran.

Pen studies were initiated in September, 1965, at the Hamilton Field Station and later continued at the Warm Springs State Bird Farm. Twenty-five juvenile pheasants (12 to 15 weeks old) and eight juvenile blue grouse (9 to 12 weeks old) were Zectran-dosed during the 1965 trials.

In 1966, five adult spruce grouse (at least 1-year-old) and four juvenile (8 to 12 weeks) and two adult blue grouse were captured and Zectran-dosed at the Hamilton Field Station. In 1967, six adult male ruffed grouse and 13 adult spruce grouse were captured for Zectran dosing. The six ruffed grouse were captured between May 15 and June 17, and 13 spruce grouse between May 31 and August 5. Because of the opportune nature of capturing ruffed and spruce grouse, 1967 Zectran-dosing was conducted in the field with captives held in small wire cages.

Acute Oral Toxicity Trials

A summary of 1965-67 acute oral dosing experiments with forest grouse and pheasants is presented in Table 9. The results indicate the high acute oral toxicity of Zectran to these game birds (acute oral doses of over 12.00 milligrams of Zectran per kilogram of body weight were fatal to 25 of 31 test birds). The acute toxicity

TABLE 9. SUMMARY OF ZECTRAN ACUTE ORAL DOSING TESTS WITH FOREST GROUSE AND PHEASANTS (1965, 1966 AND 1967 DATA COMBINED).

Zectran (mg/kg Body Weight)	Pheasants	Blue Grouse	Spruce Grouse	Ruffed Grouse
4.00	0/6[1]	0/1		0/1
5.33			0/3	
5.40	0/1			
7.00				0/1
8.00	4/6	0/3	1/3	
9.00		0/1		
10.00		0/1		
11.30		1/1		
11.40	1/2			
11.70		0/1		
11.76			0/1	
12.00	7/7	2/4	3/3	
12.25				0/2
13.09			0/1	
13.33		0/1		
14.47			1/1	
15.00		1/1	1/1	
17.09			1/1	
18.00			2/2	
19.42			1/1	
20.00	2/2			
20.56			1/1	
21.44				2/2
25.90	1/1			
LD_{50}[2]	6.9	12.0	8.6	16.2

[1] Number that died over the number dosed.

[2] Estimated, see text for explanation (Pen Methods, pp. 12).

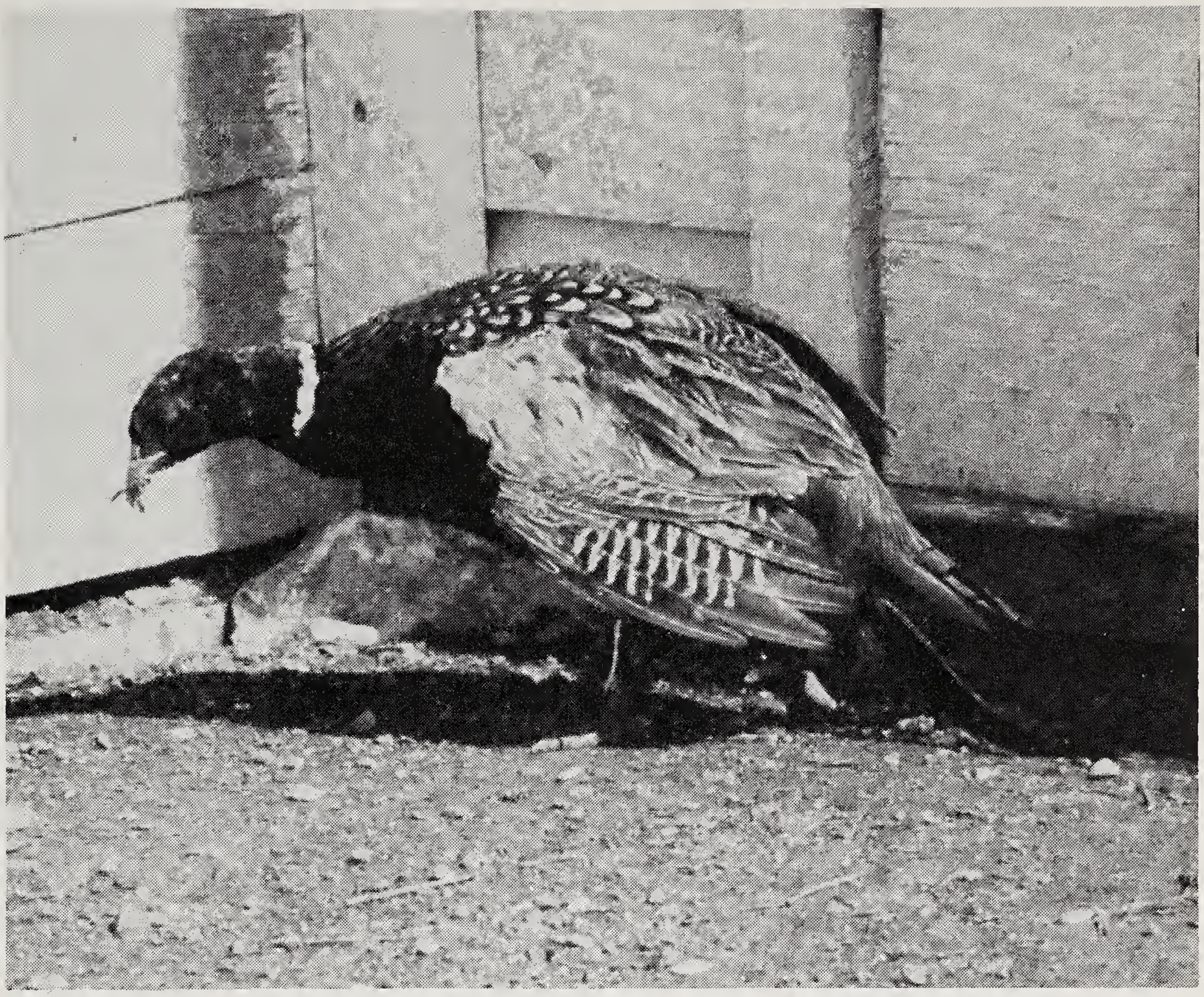


Figure 13. A pheasant orally dosed with Zectran showing the characteristic droop of the neck and wings.

of Zectran was greatest to pheasants, spruce grouse, blue grouse and ruffed grouse in that order, though the limitations of small samples and the absence of uniform fasting procedures must be considered.

Acute toxicity studies (Sherman *et al.* 1967) with 10- to 12-day-old cockerels indicated the LD_{50} of Zectran to be 4.4 mg/kg. The same authors conducted subacute feeding trials and found that cockerels could ingest up to 200 ppm of Zectran in their food with no toxic symptoms noted, although the mean weight gain of dosed birds was significantly lower ($P<0.01$) than for the control group after 1 week. They reported no correlation between acute and subacute toxicity levels.

Behavior of Dosed Birds

Symptomology associated with Zectran toxicity varied somewhat between pheasants and forest grouse. Behavior changes such as unsteadiness or unusual inactivity were most apparent among pheasants because of their more active nature. The excitability of pheasants compared to forest grouse was even more pronounced after dosing, though handling was also a factor. The first symptom noted in pheasants was an overly active and excitable period followed by increasing lethargy. Excessive eye-blinking and swallowing followed, with a progressive droop of the neck and wings (Figure 13). Later symptoms included loss of balance and falling with spasmodic wing-flapping preceding death. At death the birds usually lay on their sides with the legs rather stiffy extended posteriorly. Evidence of excessive salivation was usually noted upon examination of dead or sick birds, and many exhibited diarrhea at some time. The interval from first visible symptoms to death ranged from 5 to 67 minutes and averaged 23 minutes for 15 pheasants receiving lethal oral dosages. Grouse usually died within a similar time span.

Forest grouse were considerably less active than pheasants before and after dosing. Ruffed grouse were more active than blue or spruce grouse. The abrupt change from excitability to drowsiness noted in pheasants was not obvious among dosed grouse. The earliest noted symptoms in grouse were accelerated eye-blinking and swallowing. Increased inactivity followed, accompanied by wing-drooping and unsteadiness. Dosed grouse did not droop their heads as did pheasants. Sick grouse characteristically squatted on their breasts with occasional lateral head-wobbling. The spasmodic wing-flapping prior to death was similar for dosed pheasants and grouse.

Subacute Oral Toxicity Trials

Symptoms and their chronology in subacutely dosed birds were generally similar to those following acute oral dosing. Pheasants and grouse both exhibited periods of drowsiness and inactivity within 1 hour of dosing. Two pheasants receiving initial Zectran doses of 4.0 mg/kg followed by 2.0 mg/kg twice daily for the next 7 days showed short periods of drowsiness and slight lack of coordination. A pheasant given single doses of 4.0 mg/kg on each of 3 successive days showed no symptoms the first day, but was lethargic and had a marked lack of coordination the second and third days. Another pheasant given 4.0 mg/kg twice daily for 5 successive days exhibited the full range of symptoms up to, and including, pronounced lack of coordination on the first 3 days. Symptoms were less pronounced on the final 2 days.

Observations on a blue grouse receiving 9.0 mg/kg initially, followed by 4.3 mg/kg on each of the following 2 days, were incomplete due to a head injury. However, no advanced symptoms were observed and he survived. A second blue grouse receiving 4.0 mg/kg twice daily for 2 days exhibited only slight unsteadiness.

Weight losses were indicated for all multiply-dosed birds for which weights were obtained at the termination of the trial period. These weight losses are partially attributed to the frequent handling involved. The pheasant receiving a sugar capsule twice daily for 7 days lost 1.6 percent of his pre-dosing weight in this time. The pheasants receiving multiple, sublethal doses of Zectran lost from 3.9 to 6.9 percent of their pre-dose weights. Post-dosing weights were not obtained from either blue grouse receiving multiple Zectran doses.

DISCUSSION

Available information concerning Dibrom and Zectran (high acute oral toxicity to birds, cholinesterase inhibition properties and rapid breakdown characteristics) indicated that any potential effects on the survival or behavior of aerially sprayed forest grouse would probably occur within a relatively short time (hours or days) after exposure. Study methods which would reflect signs of insecticide poisoning in grouse (such as coordination loss) or direct mortality shortly after spraying were needed. Since these experimental insecticides lack both the affinity for fatty tissues and the longer persistence of chlorinated hydrocarbons, problems of residue storage in grouse tissues (Mussehl and Finley 1967), delayed poisoning of birds (Bernard 1963), or accumulation in the food chain (Hunt and Bischoff 1960) were not expected. A combination of methods was used to evaluate direct effects of aerially sprayed Dibrom and Zectran on blue and ruffed grouse. Pre- and postspray studies included direct observations of banded and telemetered grouse, limited electronic monitoring for changes in grouse activity and respiration and comparisons of male blue grouse breeding populations and survival rates on sprayed and unsprayed areas.

The 1965 evaluations indicated no direct adverse effects of Dibrom on forest grouse. Dibrom was eliminated as a candidate material following the 1965 tests because of relative ineffectiveness as a budworm insecticide.

The more intensive field studies of 1966 supplemented fragmentary 1965 evidence that aerial applications of Zectran had no apparent direct effects on adult blue grouse. Postspray blue grouse observations on the 1965 Zectran study unit were meager; only 4 of 11 territorial males were positively exposed to Zectran. One broodless female was continually monitored by telemetry during spray day and periodically for 8 subsequent days. No signs of poisoning were noticed during the abbreviated post-Zectran grouse observations in 1965.

The 1966 Zectran-grouse evaluations were considerably more comprehensive. In a special test, the Mud Creek unit received five consecutive swaths of Zectran applied in rapid succession. Eight hundred gallons of Zectran formulation were sprayed on the 320-acre study unit—an overall coverage 2.5 times the operational rate of 0.15 pounds Zectran per gallon per acre.

The strongest evidence that Zectran did not affect blue grouse survival or behavior was obtained from the 1966 multiple-sprayed Mud Creek unit. Seven of 11 banded adult males positively exposed to Zectran survived to the following breeding season (10 months postspray). An eighth banded male exposed to Zectran survived until fall (4 months postspray), when taken by a hunter. Telemetry showed survival and apparent normal behavior among seven brood hens present on the multiple-sprayed area for periods of from 1 to 37 days following spraying.

Repeated postspray flush counts of the broods with instrumented hens provided no indication of induced chick mortality in six of seven broods on the multiple-sprayed area. Chick loss occurred in one brood shortly after spraying; whether this was a direct effect of the pesticide or natural mortality was not clear. A better field evaluation of chick survival in relation to Zectran might be accomplished by systematic flush counts of telemetered broods on both sprayed and unsprayed areas.

Less intensive findings were obtained from the 1966 pilot operational test (Trapper Creek) where Zectran was applied for spruce budworm control at 0.15 pounds per gallon per acre. This application (June 30 to July 4) was made after major exodus of blue grouse from that area began. Only 9 of the 45 territorial males on Trapper Creek study units were positively known to be exposed to Zectran. Five of 21 females banded on Trapper Creek units were re-observed after spraying. Three of these five females were radio-equipped and were monitored within the sprayed area for periods of from 7 to 19 days after application. The Trapper Creek application provided the only field evaluation obtained for Zectran and its effects on ruffed grouse. Four of five banded ruffed grouse males were observed (by telemetry or band returns) to have survived for varying postspray intervals.

Significant differences in annual survival rates of banded blue grouse males between various sprayed and unsprayed study units were not indicated. The value of this study approach was limited considerably on some units because of the exodus of banded males before spraying.

Compared to conventional marked grouse observation techniques, telemetry provided some of the best data for insecticide-grouse evaluations. During 28 days of the immediate pre- and postspray period in 1966, telemetry provided 326 relocations of 13 instrumented blue grouse. In the same period, only 15 of more than 75 banded but non-instrumented blue grouse on the same areas were located and identified. The only marked ruffed grouse located in the postspray observation period were instrumented with transmitters.

Telemetry provided several advantages that enhanced the evaluation of the possible effects of Dibrom and Zectran on forest grouse. The movements of instrumented grouse within spray boundaries were determined. Three of 4 and 11 of 13 instrumented grouse exposed to spraying in 1965 and 1966, respectively, remained in sprayed zones for at least 1 week after spraying – the period when these relatively short-lived chemicals would potentially be most hazardous. None of the instrumented grouse were known to die or show signs of poisoning. The possibility of finding pesticide casualties by telemetry was demonstrated by radio-tracking instrumented females to their nest sites. The potential for electronically detecting sub-lethal effects of Zectran was demonstrated by monitoring signal changes from orally dosed grouse under pen and wild conditions. An instrumented brood hen lost her chicks in both 1966 and 1967 when she was temporarily incapacitated by sublethal oral dosages of Zectran during field experiments. Limited telemetry studies did not reveal changes in respiration or gross activity patterns of instrumented grouse after exposure to aerially sprayed Zectran in 1966.

Improved prespray preparations occurred when two spring seasons of field work were available prior to spraying (1966 tests on Mud Creek). The success of these preparations would not have been possible without prior knowledge of methods of locating and capturing blue grouse. Success in locating and banding ruffed and spruce grouse was not achieved until the second and third years of this project, respectively. Knowledge of the numbers of blue grouse on Mud Creek and the extent and chronology of their seasonal movements resulted in a successful recommendation that the 1966 spray application be done before grouse left that study unit. Conversely, spray application on the Trapper Creek units (which was necessarily tied to the development of spruce budworm) occurred after the blue grouse exodus was well underway. The value of *spraying a wildlife study area as opposed to studying wildlife on a sprayed area* is worthy of increased consideration in future forest wildlife-pesticide evaluations.

A comprehensive study of the longevity, magnitude and toxicity of Zectran residues on various food plants used by forest grouse in summer was not attained. Existing Zectran residue findings (Pieper and Miskus 1967) were not accompanied by corresponding information on spray deposits. Knowledge of the levels and duration of Zectran residues at maximum deposit sites would be more useful from the standpoint of pesticide-wildlife evaluations.

Safety to wildlife of short-residual, high-toxicity sprays such as Dibrom and Zectran appears to depend upon characteristics of application. Gross mis-applications or heavy overdoses, inherent to some degree with large aerial applications on mountainous terrain, could create hazards to local fauna.

Within the limitations of the methods used, no positive evidence of forest grouse mortality from aerially sprayed Dibrom or Zectran was found. Lack of such evidence does not assure that detrimental effects of these chemicals to blue grouse or other forest grouse might not occur. However, the positive evidence of *survival* of this sample of exposed grouse is a valuable step towards a more compatible forest pesticide-wildlife relationship.

SUMMARY

Fragmentary evidence in 1965 gave no indication that aerially sprayed Dibrom (0.4 pounds per acre) or Zectran (0.15 pounds per acre) were detrimental to small samples of blue grouse. Only 10 of 16 and 4 of 11 territorial male blue grouse were known to be exposed during the 1965 Dibrom and Zectran applications, respectively. A broodless female was continually monitored by radio telemetry during Zectran spraying and periodically for 8 subsequent days. No signs of Dibrom or Zectran poisoning were noted during the abbreviated postspray observations of grouse in 1965. Thirteen of 15 and 5 of 8 banded males returned to the 1965 Dibrom and Zectran study units the following spring, respectively. Dibrom was eliminated as a candidate spruce budworm insecticide after the 1965 field trials.

Preparations for the 1966 Zectran-grouse evaluations were strengthened considerably. One hundred blue and five ruffed grouse were banded on proposed treatment and control areas. The 1966 studies included a special test where five consecutive swaths of Zectran were applied in rapid succession to the Mud Creek blue grouse study unit. In this special test 800 gallons of Zectran formulation were applied to the 320-acre unit, resulting in an overall coverage 2.5 times the operational rate (0.15 pounds of Zectran per gallon per acre).

On the multiple-sprayed unit, 14 female blue grouse and 17 of 19 territorial males were banded before spraying. In addition to being banded, 10 females and 2 males were radio-equipped before spraying on this unit. Twelve of the banded males (two instrumented) and seven instrumented females were known to be present during the multiple Zectran application.

During 1966, blue and ruffed grouse were also exposed to Zectran at the recommended operational application rate (0.15 pounds per acre) on a pilot spruce budworm control test on Trapper Creek. Thirty-one of 45 territorial blue grouse males and 21 females were banded there before spraying, including three blue grouse hens that were radio-equipped. Two of five banded ruffed grouse males were also radio-equipped before spraying.

The more intensive 1966 field studies supplemented fragmentary evidence from 1965 that Zectran had no positive detrimental effects on adult blue grouse exposed to aerial applications. The strongest evidence came from the multiple-sprayed Mud Creek study unit. Telemetry indicated the survival of nine adult blue grouse tracked there within the treated area for 1 to 37 postspray days. Seven of 11

banded adult males known to be exposed to Zectran survived to the following breeding season (10 months later). An eighth banded male exposed to Zectran survived until fall when taken by a hunter.

Less comprehensive findings were obtained from the operational pilot test where Zectran was applied after the major exodus of blue grouse began. Only 9 of the 45 territorial males on Trapper Creek study units were positively known to be exposed to Zectran. Five of 21 females banded on Trapper Creek units were re-observed after spraying. Three of these five females were radio-equipped and were monitored within the sprayed area for 7 to 19 days after application.

Comparison of survival rates of banded blue grouse males on sprayed and unsprayed areas did not indicate induced male mortality on either individual or combined study units. This study method was limited by the egress of banded males from some units prior to spraying.

Symptoms of Zectran poisoning were not detected in any forest grouse observed after aerial spraying.

The evaluation of Zectran and its effects on ruffed grouse was limited: four of five banded males were known (telemetry or band returns) to have survived for varying postspray intervals.

The value of telemetry for pesticide-grouse evaluations was demonstrated. Most data obtained in the critical postspray period were by telemetry. All instrumented grouse (3 blue grouse in 1965, and 13 blue and 2 ruffed grouse in 1966) exposed to spraying survived during the immediate postspray period. Flush counts of chicks with instrumented hens in 1966 did not indicate an induced mortality in eight of nine broods. Chick loss was noted in one brood shortly after spraying; whether this loss was because of the pesticide application or merely coincidental was not clear. The potential of telemetry to detect sublethal effects of an insecticide was demonstrated in limited experiments that monitored grouse activity and respiration changes. During field experiments, an instrumented blue grouse hen lost her chicks in both 1966 and 1967 when she was temporarily incapacitated by sublethal oral dosages of Zectran.

Pen tests with pheasants and three species of forest grouse (blue, ruffed and spruce) indicated the high acute oral toxicity of Zectran to birds (12.0 mg/kg or above was fatal to 25 of 31 test birds).

LITERATURE CITED

Adams, L., M. G. Hanavan, N. W. Hosley, and D. W. Johnston. 1949. The effects on fish, birds and mammals of DDT used in the control of forest insects in Idaho and Wyoming. J. Wildl. Mgmt. 13(3):245-254.

Bendell, J. F. and P. W. Elliott. 1967. Behavior and the regulation of numbers in blue grouse. Canadian Wildlife Service Report Series. No. 4. 76 pp.

Bernard, R. F. 1963. Studies on the effects of DDT on birds. Mich. State Univ. Mus. Pub. 2(3):155-192.

Boag, D. A. 1966. Population attributes of blue grouse in southwestern Alberta. Can. J. Zool. 44:799-814.

Brander, R. B. 1968. A radio-package harness for game birds. J. Wildl. Mgmt. 32(3):630-632.

Carson, Rachel. 1962. *Silent Spring.* Houghton-Mifflin Co., Boston. 368 pp.

Casebeer, R. L. 1965. Monitoring the 1964 spruce budworm aerial spray project. Forest Service, U. S. Dept. Agri. Ogden, Utah. 48 pp.

Cochran, W. W. and R. D. Lord, Jr. 1963. A radio-tracking system for wild animals. J. Wildl. Mgmt. 27(1):9-24.

Daubenmire, R. 1953. Classification of the conifer forests of eastern Washington and northern Idaho. Northwest Sci. 27(1):17-24.

Finley, R. B., Jr. 1965. Adverse effects on birds of phosphamidon applied to a Montana forest. J. Wildl. Mgmt. 29(3):580-591.

Graham, R. 1958. The effects of aerial spraying on fish and wildlife. Presented at the 49th Western Forestry Conference, San Francisco, Calif. 5 pp.

Gullion, G. W. 1965. Improvements in methods for trapping and marking ruffed grouse. J. Wildl. Mgmt. 29(1):109-116.

Hamerstrom, F. N., Jr. and O. E. Mattson. 1964. A numbered, metal color-band for game birds. J. Wildl. Mgmt. 28(4):850-852.

Himel, C. M., L. Vaughn, R. P. Miskus, and A. D. Moore. 1965. A new method for spray deposit assessment. Pacific Southwest Forest and Range Expt. Sta. Research Note 87. 10 pp.

Hoffman, R. S., R. G. Janson, and F. Hartkorn. 1958. Effects on grouse populations of DDT spraying for spruce budworm. J. Wildl. Mgmt. 22(1):92-93.

Hunt, E. G. and A. I. Bischoff. 1960. Inimical effects on wildlife of periodic DDD applications to Clear Lake. Calif. Fish and Game. 46(1):91-106.

Jenkins, D. 1961. Social behavior in the partridge *Perdix perdix.* Ibis. 103a: 155-188.

Lang, Jean M. and R. P. Miskus. 1967. Zectran fed orally to mice... cholinesterase levels in blood determined. Pacific Southwest Forest and Range Expt. Sta. Research Note 140. 3 pp.

Marshall, W. H. 1963. Studies of movements, behavior and activities of ruffed grouse using radio telemetry techniques. Progress Report, Univ. of Minn. 30 pp.

-----. 1965. Ruffed grouse behavior. BioScience. 15(2):92-94.

-----, and J. J. Kupa. 1963. Development of radio-telemetry techniques for ruffed grouse studies. Trans. N. Am. Wildl. and Nat. Res. Conf. 28:443-456.

McEwen, L. C. and R. L. Brown. 1966. Acute toxicity of dieldrin and malathion to wild sharp-tailed grouse. J. Wildl. Mgmt. 30(3):604-611.

Moore, A. D. 1966a. General information on Zectran for spruce budworm control. Pacific Southwest Forest and Range Expt. Sta., Forest Service, U. S. Dept. of Agri. 4 pp.

-----. 1966b. Research on safer chemical treatments for forest insect control. Paper presented to Northwest Section, The Wildlife Society, LaGrande, Oregon. March 26. 6 pp.

Mussehl, T. W. 1960. Blue grouse production, movements and populations in the Bridger Mountains, Montana. J. Wildl. Mgmt. 24(1):60-68.

-----. 1963. Blue grouse brood cover selection and land-use implications. J. Wildl. Mgmt. 27(4):546-555.

----- and R. B. Finley, Jr. 1967. Residues of DDT in forest grouse following spruce budworm spraying. J. Wildl. Mgmt. 31(2):270-287.

----- and P. Schladweiler. 1967. Blue grouse population and life history study. Montana Federal Aid Job Compl. Rept. Project W-91-R-8, Job No. II-C. 13 pp.

Pieper, G. R. and R. P. Miskus. 1967. Determination of Zectran residues in aerial forest spraying. Agri. and Food Chem. 15(5):915-916.

Pillmore, R. and R. B. Finley, Jr. 1963. Residues in game animals resulting from forest and range insecticide applications. Trans. N. Am. Wildl. and Nat. Resources Conf. 28:409-421.

President's Science Advisory Committee. 1963. Use of pesticides. A Report of the President's Sci. Advisory Comm., Washington, D. C. May 15. 25 pp.

Rosene, W., Jr. and D. W. Lay. 1963. Disappearance and visibility of quail remains. J. Wildl. Mgmt. 27(1):139-142.

Rudd, R. 1964. *Pesticides and the Living Landscape.* The Univ. of Wis. Press. 320 pp.

Schladweiler, P. 1968. Blue grouse population and life history study. Montana Federal Aid Job Compl. Rept. Project W-91-R-9, Job No. II-C. 12 pp.

———— and T. W. Mussehl. 1969. Use of mist-nets for recapturing radio-equipped blue grouse. J. Wildl. Mgmt. 33(2):443-444.

Sherman, M., R. B. Herrick, E. Ross and M. T. Y. Chang. 1967. Further studies on the acute and subacute toxicity of insecticides to chicks. Toxicol. Appl. Pharmacol. 11(1):49-67.

Smith, E. H. and T. W. Mussehl. 1964. Pesticides, wildlife management and the public forest. pp. 186-192. *In* Proc. Soc. Am. Foresters, Denver, Colorado.

Stirling, I. and J. F. Bendell. 1966. Census of blue grouse with recorded calls of a female. J. Wildl. Mgmt. 30 (1):184-187.

U. S. Department of the Interior. 1963 Pesticide-Wildlife Studies: A review of Fish and Wildlife Service investigations during 1961 and 1962. U. S. Fish and Wildlife Service Circ. No. 167. 109 pp.

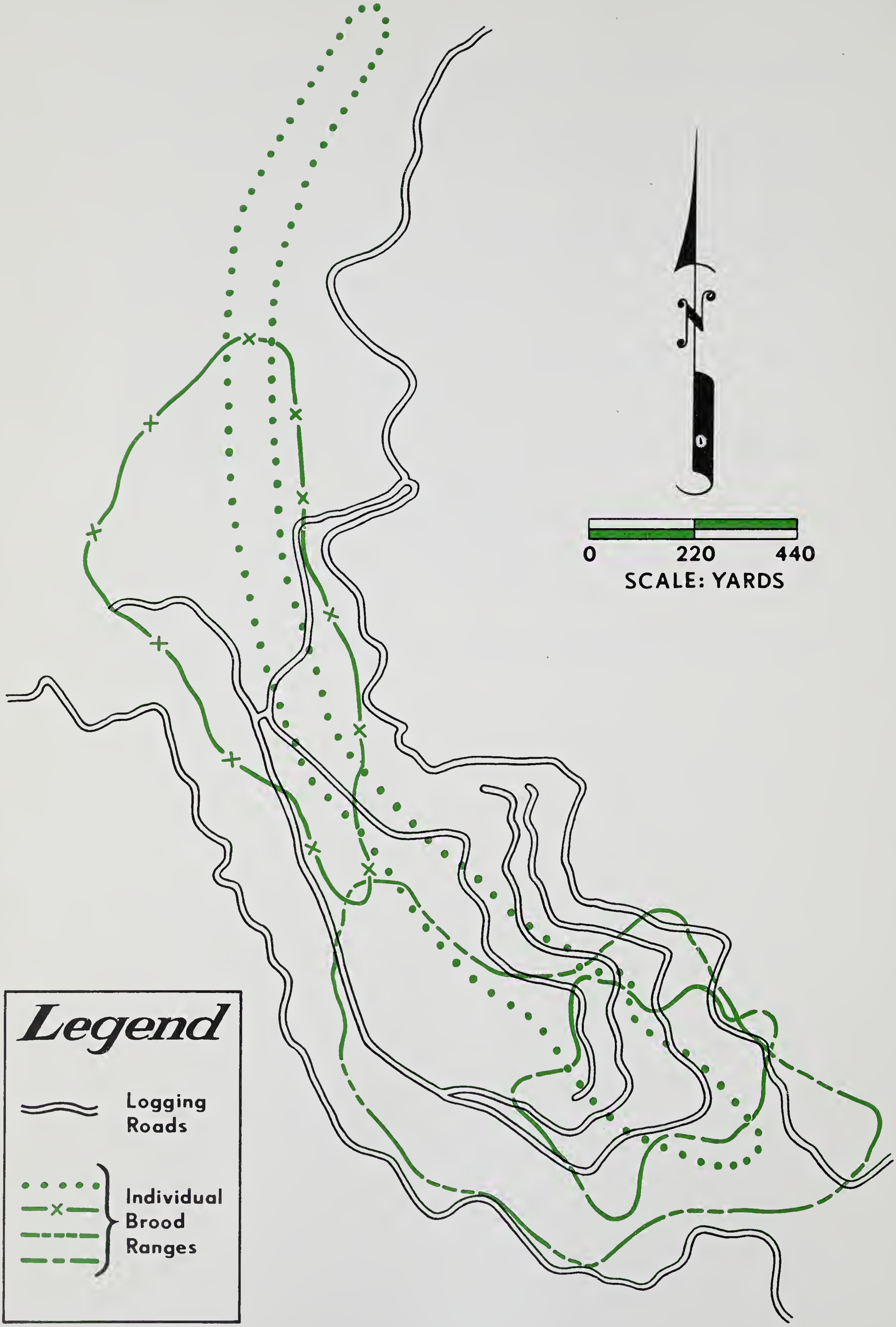
U. S. Forest Service. 1967. Zectran – for control of spruce budworm. Research fact sheet. Pacific Southwest Forest and Range Expt. Sta. Forest Service, U. S. Dept. of Agri. 6 pp.

Whiteside, J. M. and V. M. Carolin. 1961. Spruce budworm in the western United States. U. S. Dept. of Agri., Forest Pest Leaflet No. 53. 8 pp.

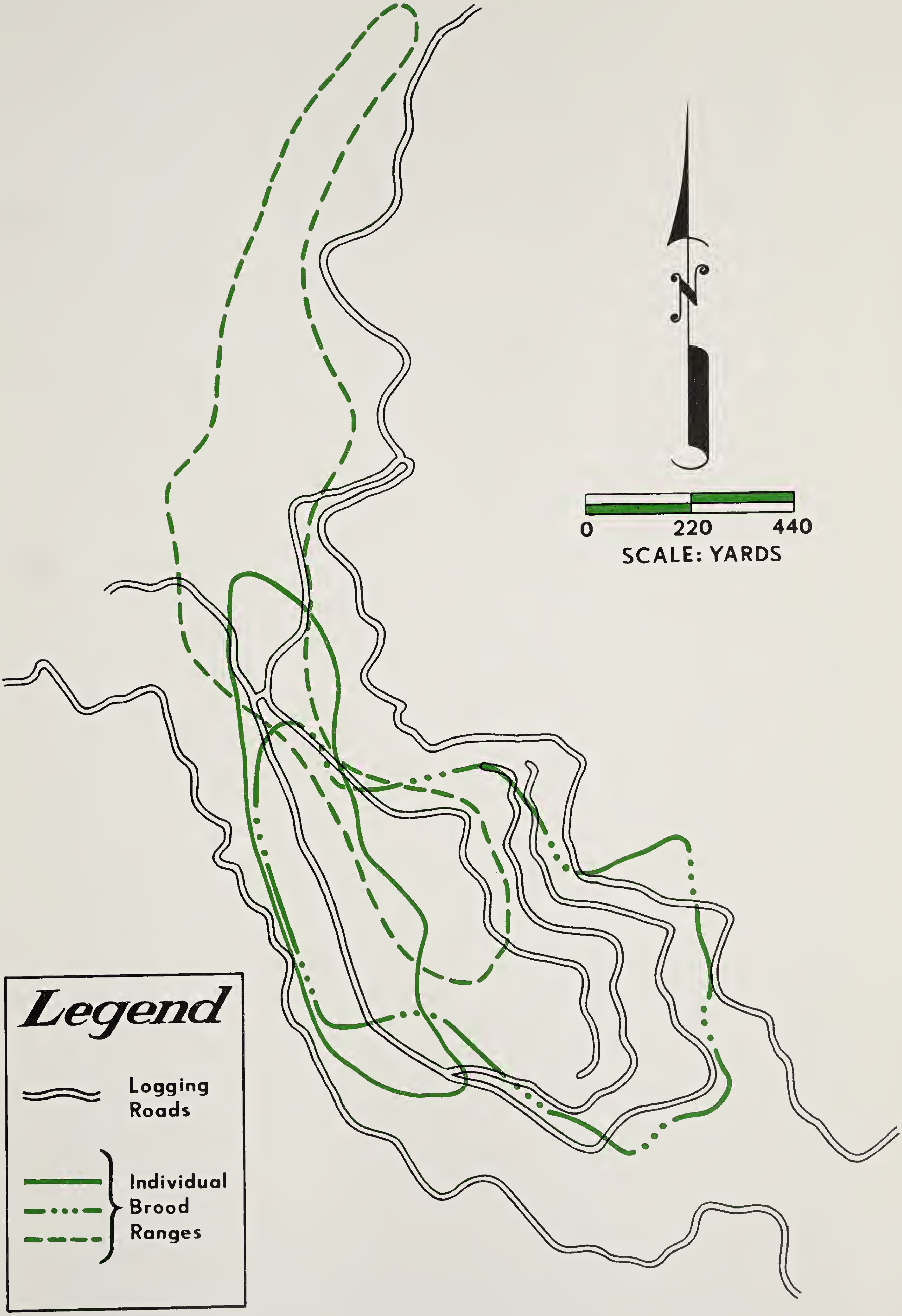
Wing, L., J. Beer, and W. Tidyman. 1944. Brood habits and growth of "Blue Grouse." Auk. 61(3):426-440.

Zwickel, F. C. and J. F. Bendell. 1967. A snare for capturing blue grouse. J. Wildl. Mgmt. 31(1):202-204.

APPENDIX

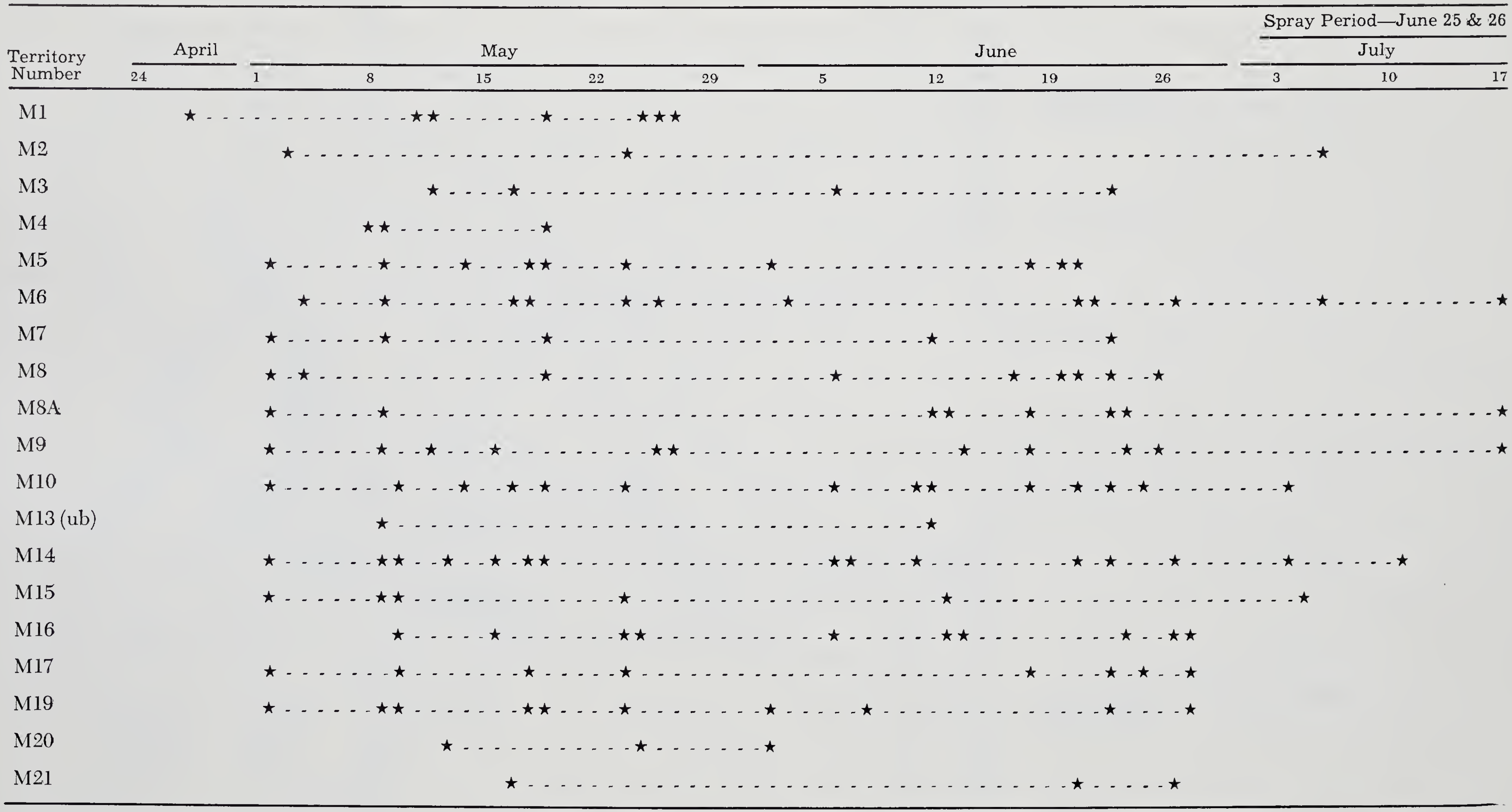


Appendix Figure 1. Movements of four instrumented blue grouse broods on the Mud Creek Zectran Study Unit during June-July, 1966 and prior to dispersal.



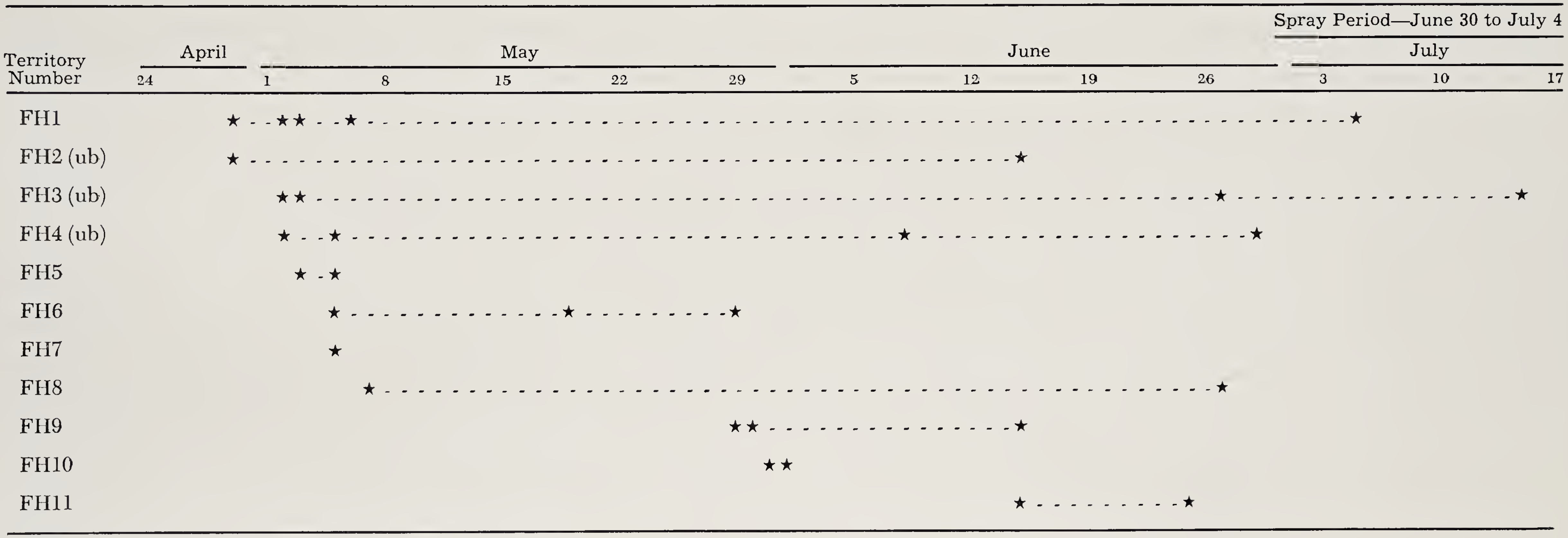
Appendix Figure 2. Movements of three instrumented blue grouse broods on the Mud Creek Zectran Study Unit during June-July, 1966 and prior to dispersal.

APPENDIX TABLE 1. OBSERVATIONS OF BANDED TERRITORIAL MALE BLUE GROUSE ON THE MUD CREEK ZECTRAN EXPERIMENTAL UNIT. APRIL 24 TO JULY 17, 1966.



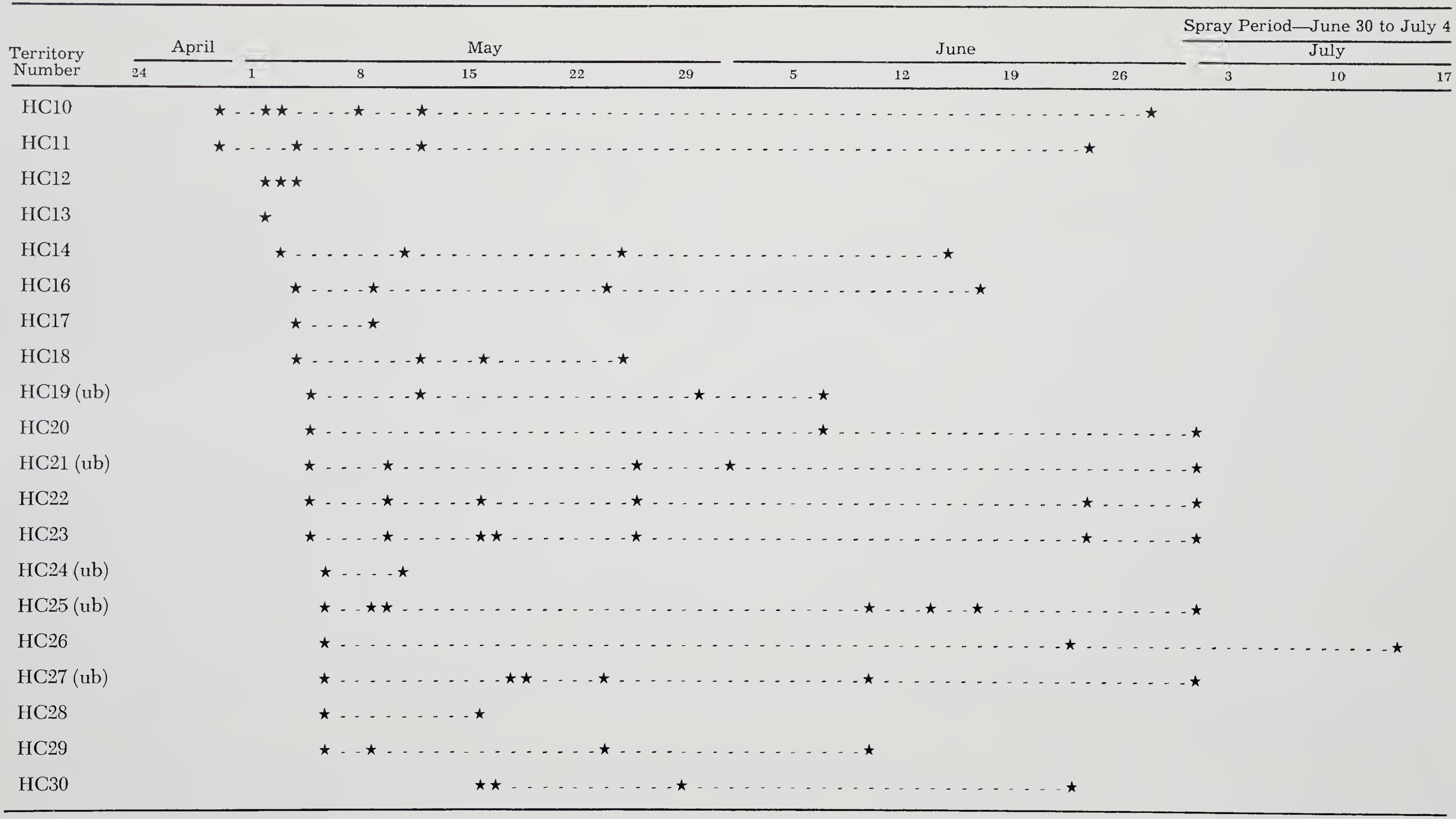
* Indicates date male observed on territory.
(ub) Indicates unbanded male.

APPENDIX TABLE 2. OBSERVATIONS OF BANDED TERRITORIAL MALE BLUE GROUSE ON THE TRAPPER CREEK (FISHHOOK) ZECTRAN EXPERIMENTAL UNIT. APRIL 24 TO JULY 17, 1966.

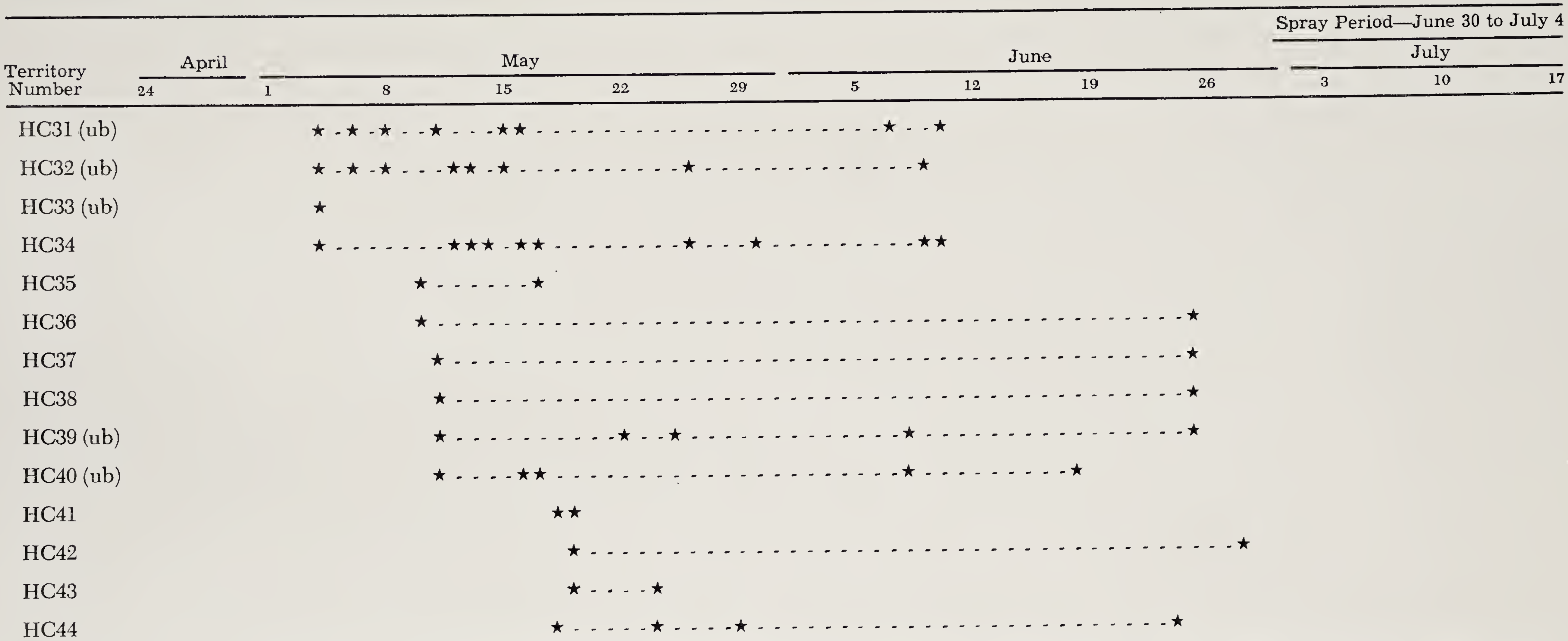


* Indicates date male observed on territory.
(ub) Indicates unbanded male.

APPENDIX TABLE 3. OBSERVATIONS OF BANDED TERRITORAL MALE BLUE GROUSE ON THE TRAPPER CREEK (HALEY CHUTE) ZECTRAN EXPERIMENTAL UNIT. APRIL 24 TO JULY 17, 1966.



APPENDIX TABLE 3. (CONTINUED)



* Indicates date male observed on territory.
(ub) Indicates unbanded male.

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